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Pratt & Whitney Aircraft DIVISION OF UNITED AIRCRAFT CORPORATION

CR#

EAST HARTFORD 8, CONNECTICUT

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Chief, Space Power Systems

R. C. Huttinger
Program Manager

Pratt & Whitney Aircraft DIVISION OF UNITED AIRCRAFT CORPORATION

EAST HARTFORD • CONNECTICUT

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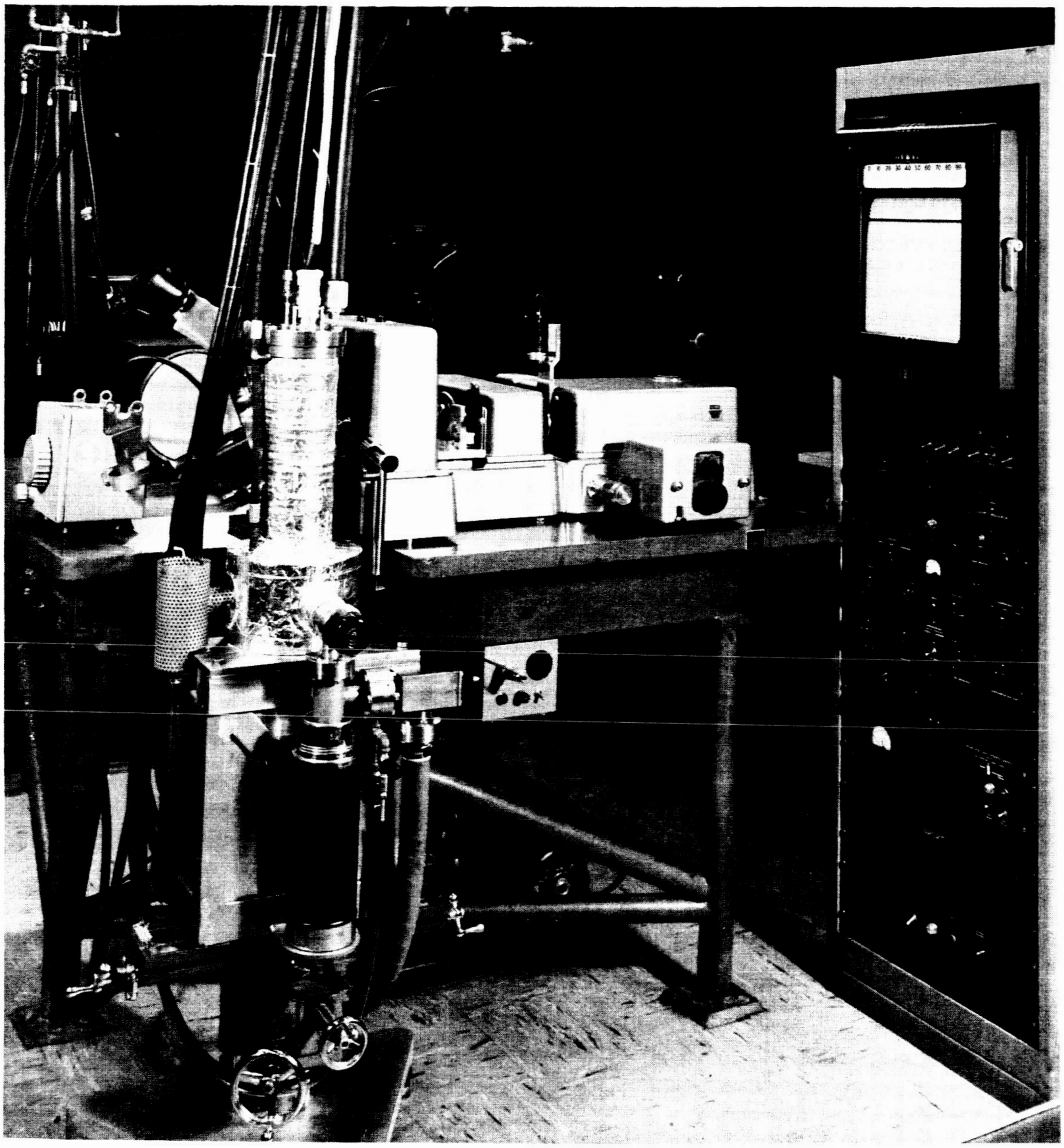
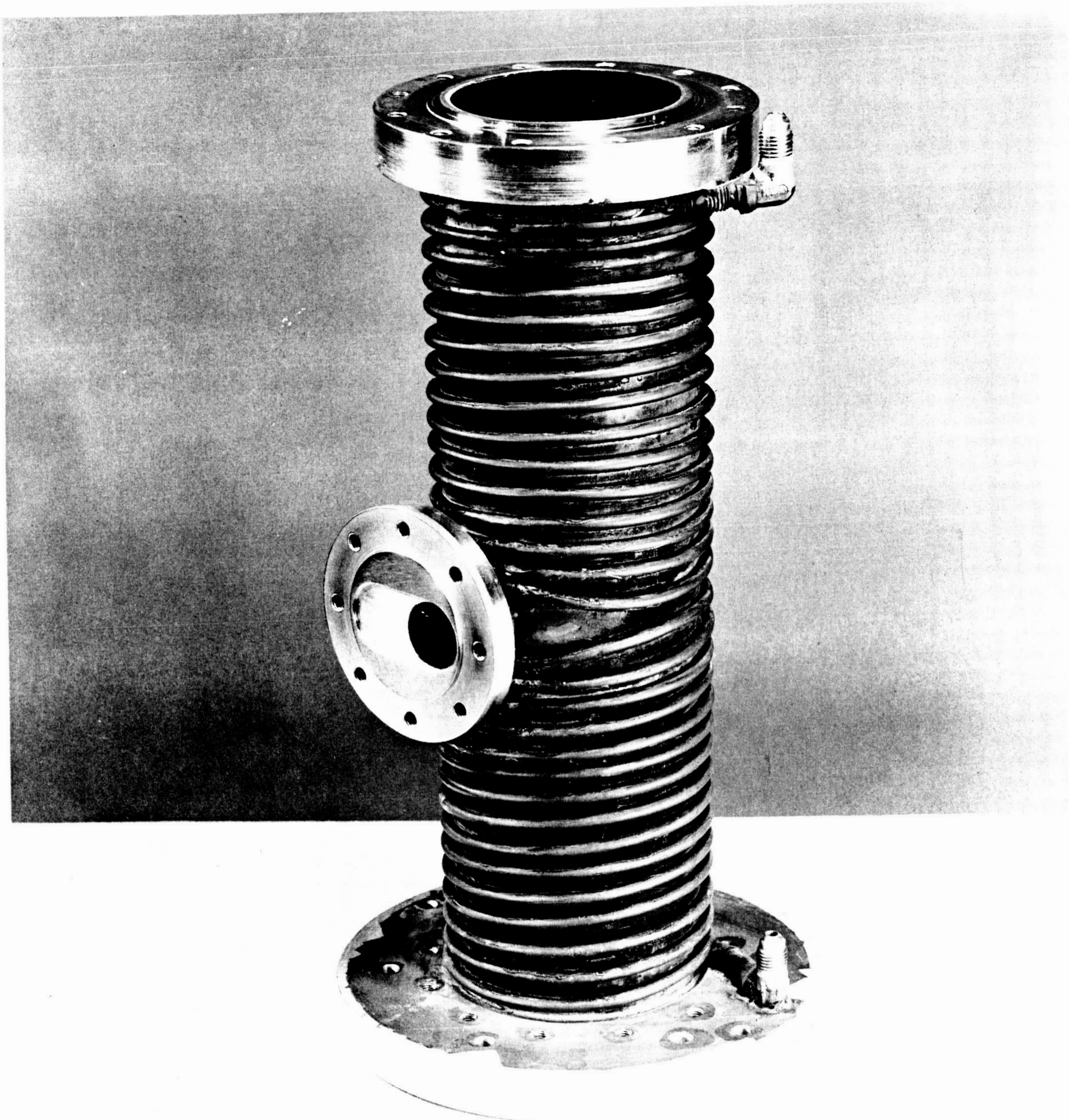


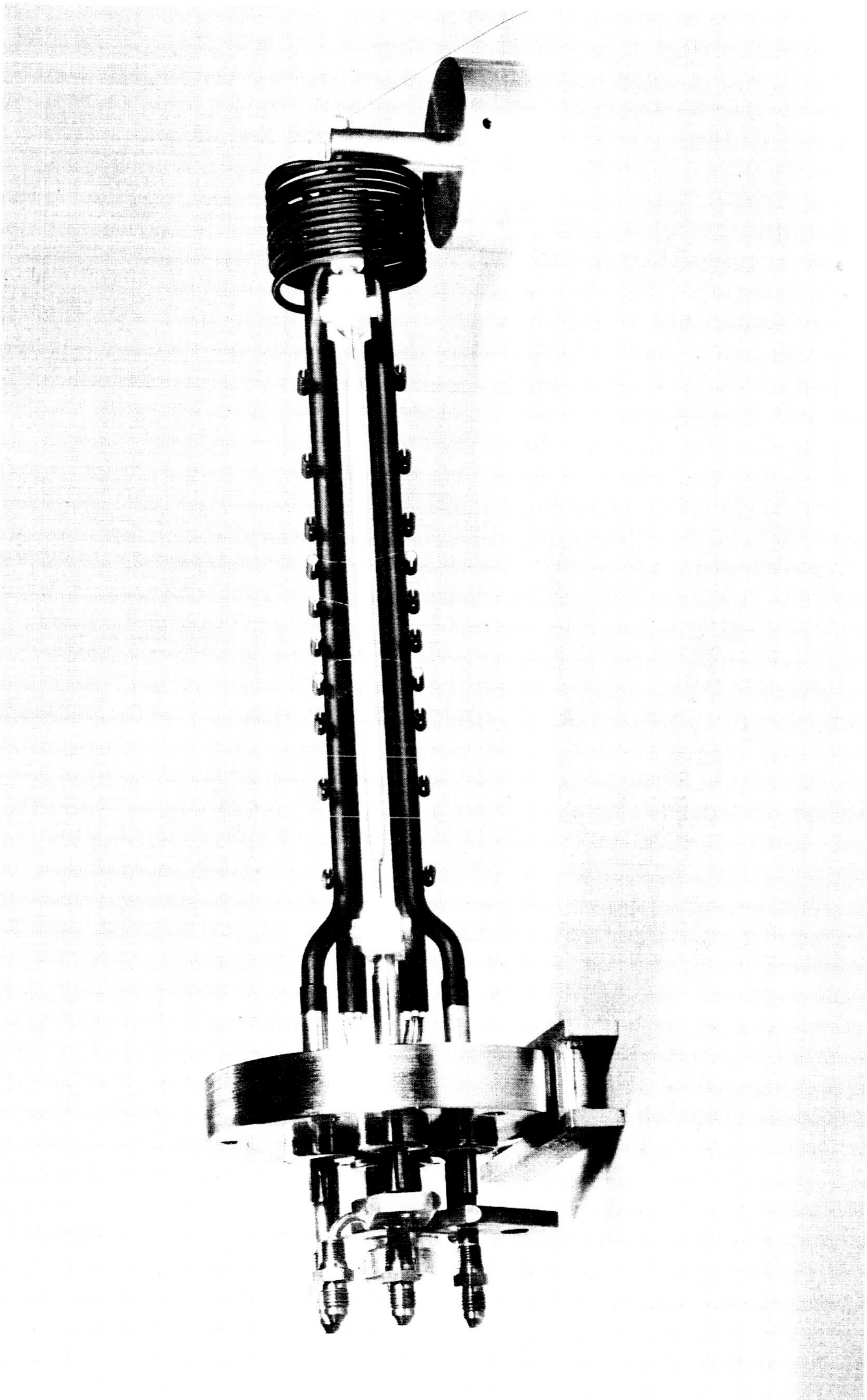
SPECTRAL NORMAL EMITTANCE RIG
1. VACUUM CHAMBER
2. RECORDER
3. OPTICAL PYROMETER
4. SPECTROPHOTOMETER

Figure 1



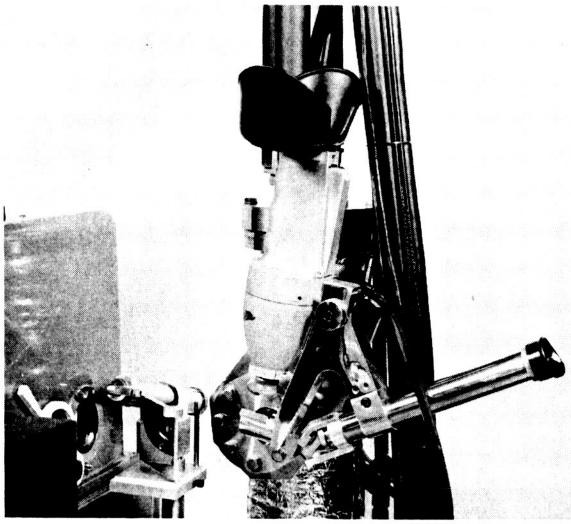
VACUUM CHAMBER FOR SPECTRAL NORMAL EMITTANCE RIG

Figure 2



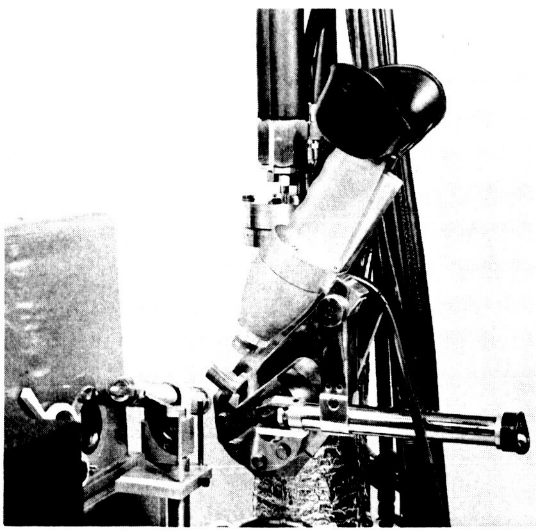
INSTRUMENTATION FLANGE ASSEMBLY AND SPECIMEN FOR SPECTRAL NORMAL EMITTANCE RIG

Figure 3

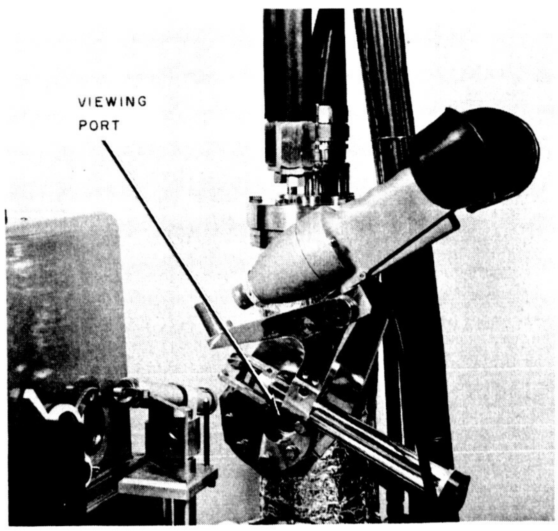


TEMPERATURE MEASUREMENT POSITION

OPTICAL PYROMETER
AND
ALIGNMENT MICROSCOPE ASSEMBLY
ON SPECTRAL NORMAL EMITTANCE RIG



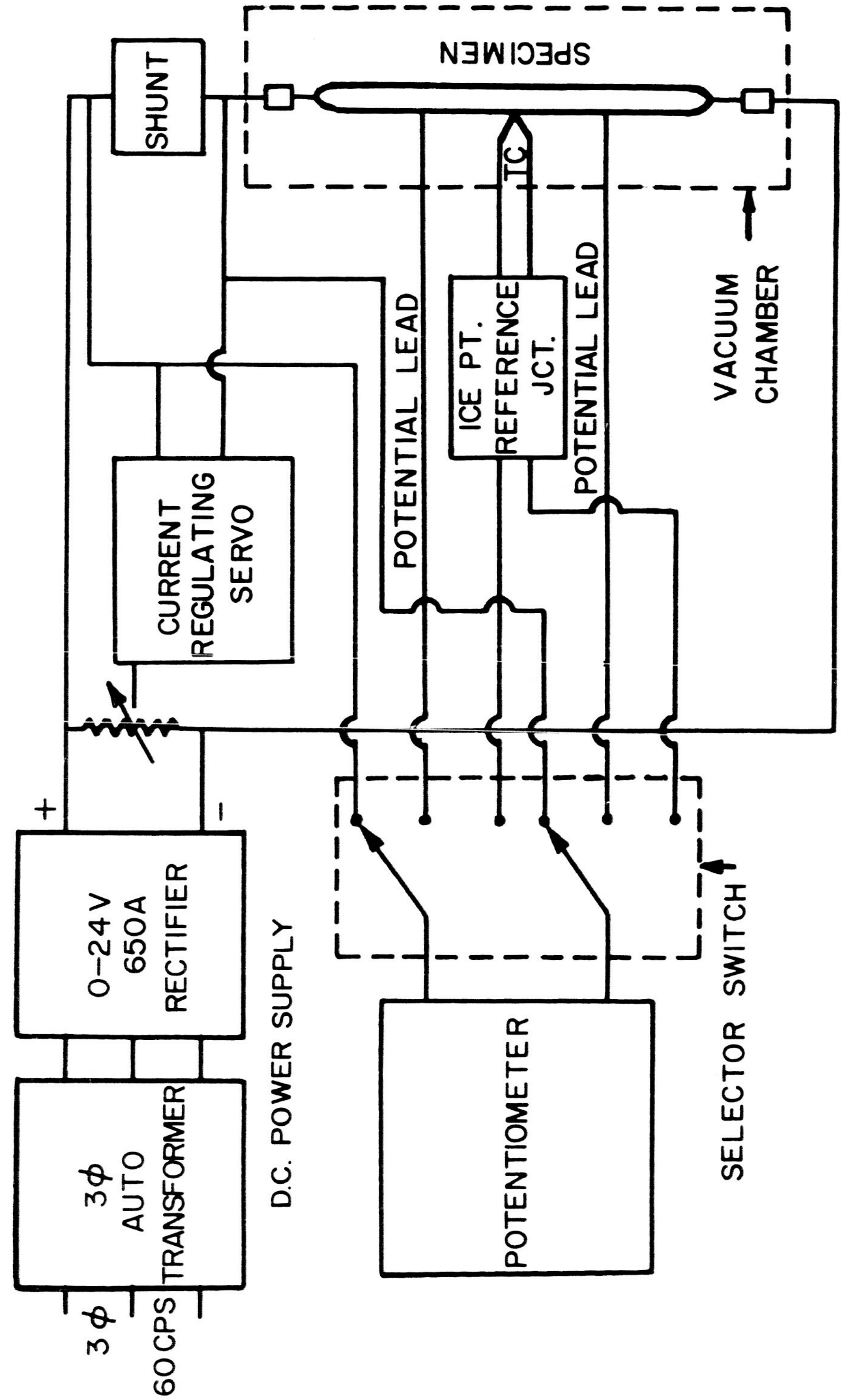
SPECIMEN ALIGNMENT POSITION

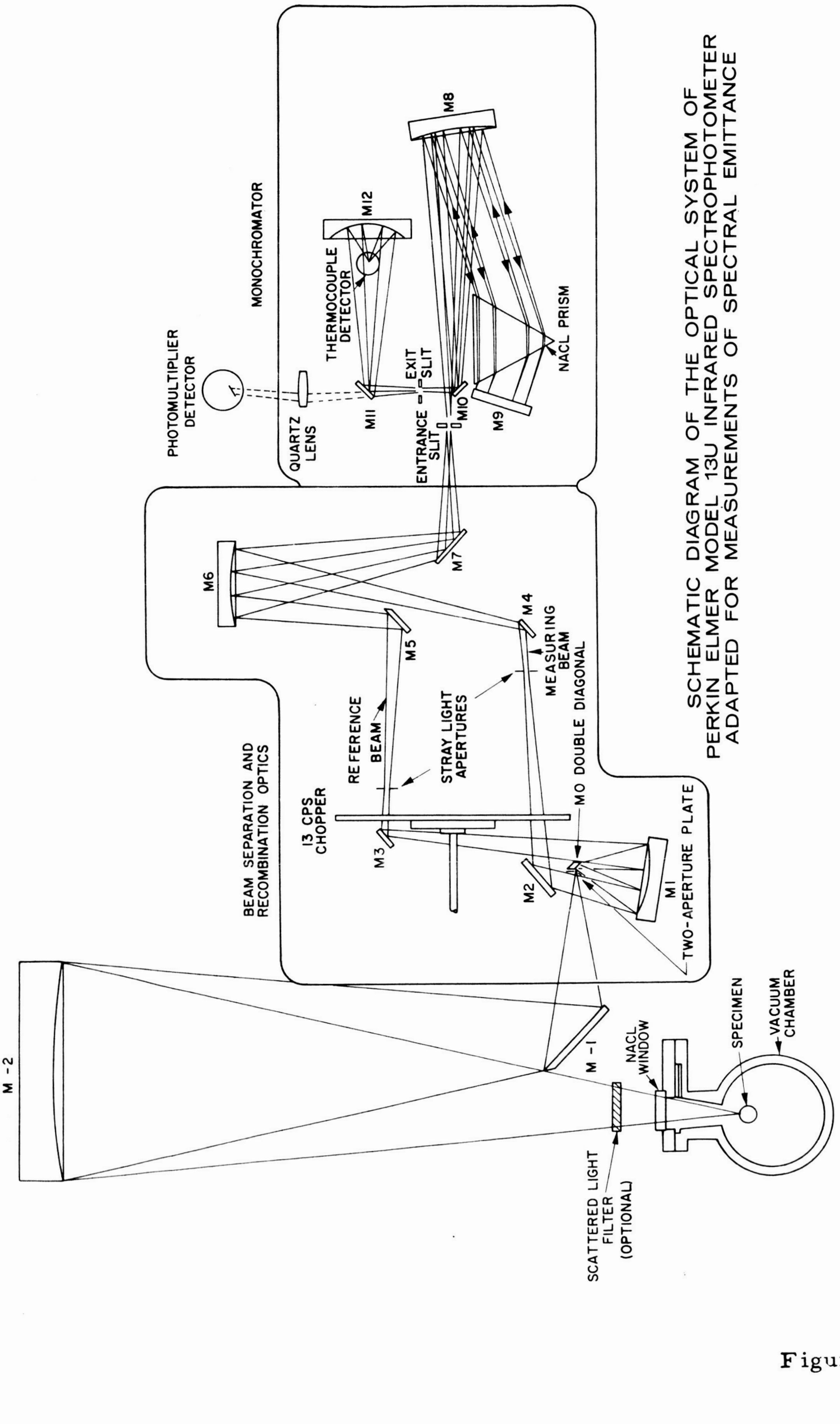


SPECTRAL NORMAL EMITTANCE MEASUREMENT POSITION

Figure 4

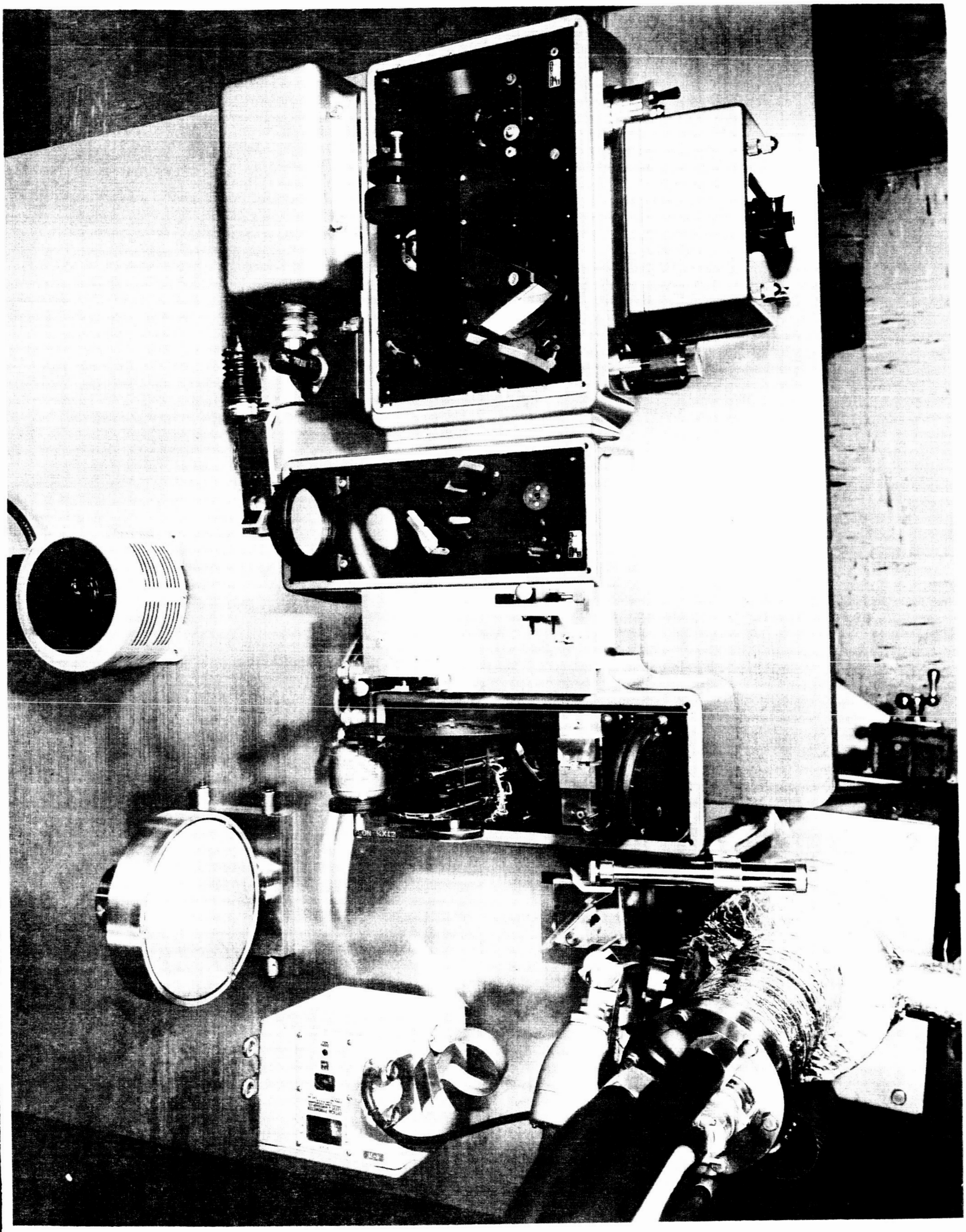
SCHEMATIC WIRING DIAGRAM OF REGULATED POWER SUPPLY AND MEASURING CIRCUITS FOR THE SPECTRAL EMITTANCE RIG





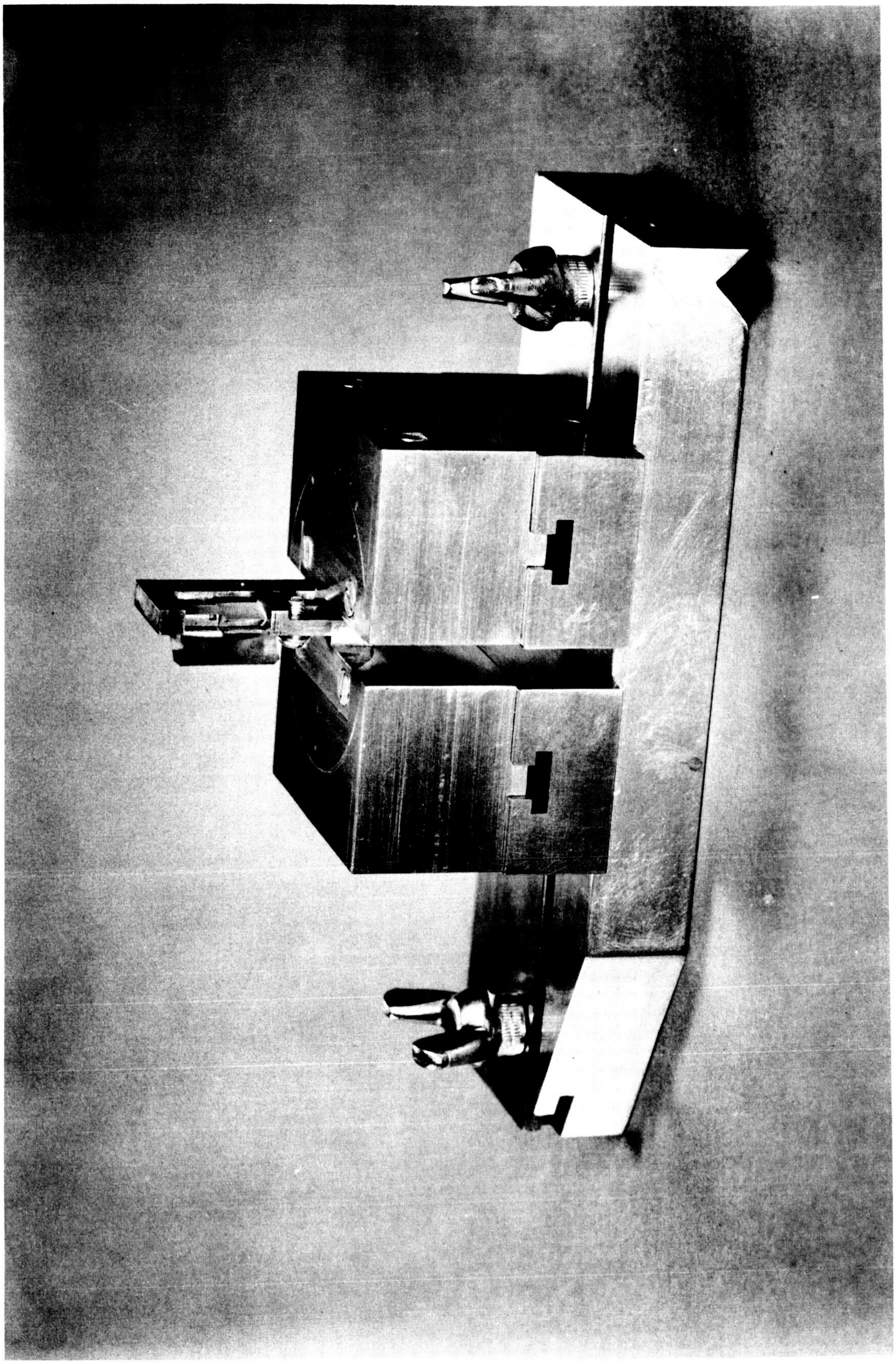
SCHEMATIC DIAGRAM OF THE OPTICAL SYSTEM OF PERKIN ELMER MODEL 13U INFRARED SPECTROPHOTOMETER ADAPTED FOR MEASUREMENTS OF SPECTRAL EMITTANCE

Figure 6



SPECTRAL EMITTANCE RIG OPTICAL SYSTEM WITH MODIFIED INFRARED SPECTROPHOTOMETER

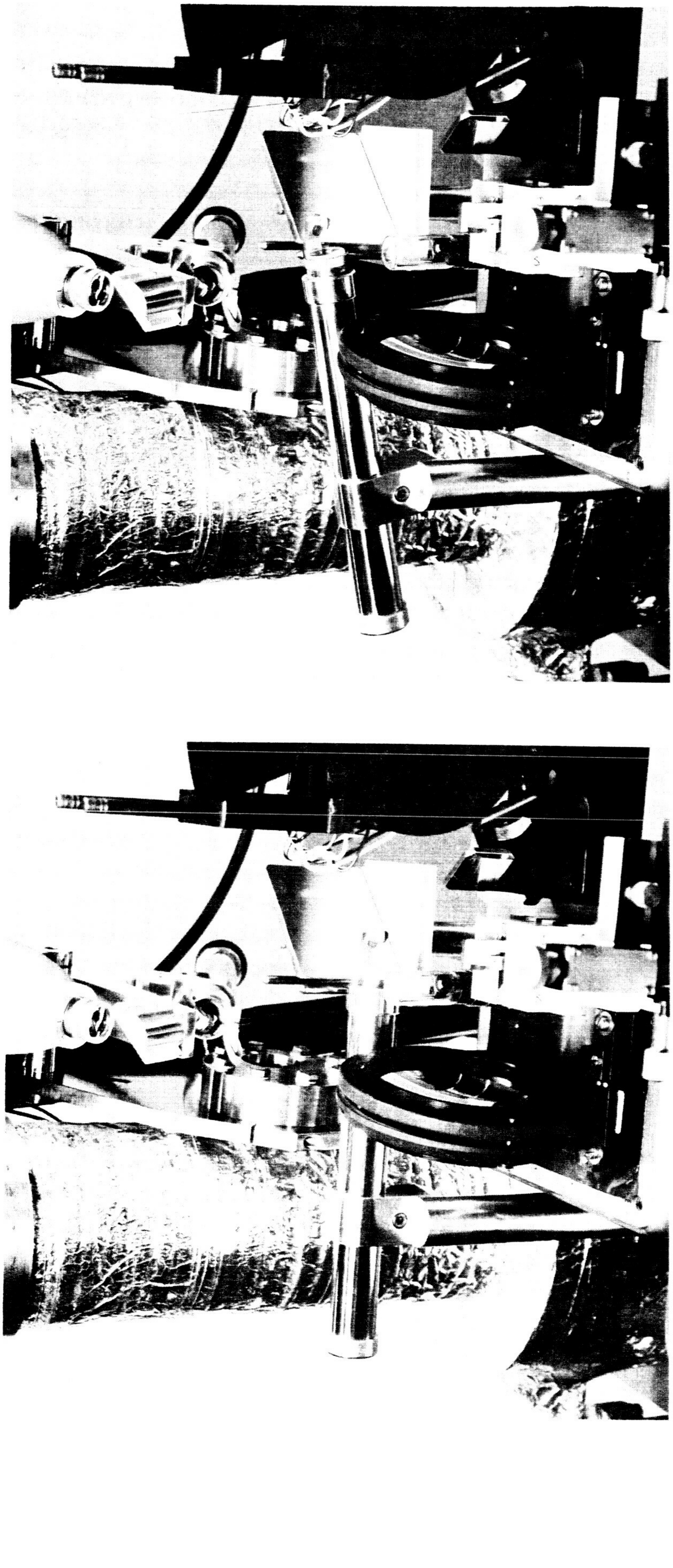
Figure 7



BEAM SEPARATOR FOR SPECTRAL NORMAL EMITTANCE RIG

PRATT & WHITNEY AIRCRAFT DEPENDABLE ENGINES

Figure 8

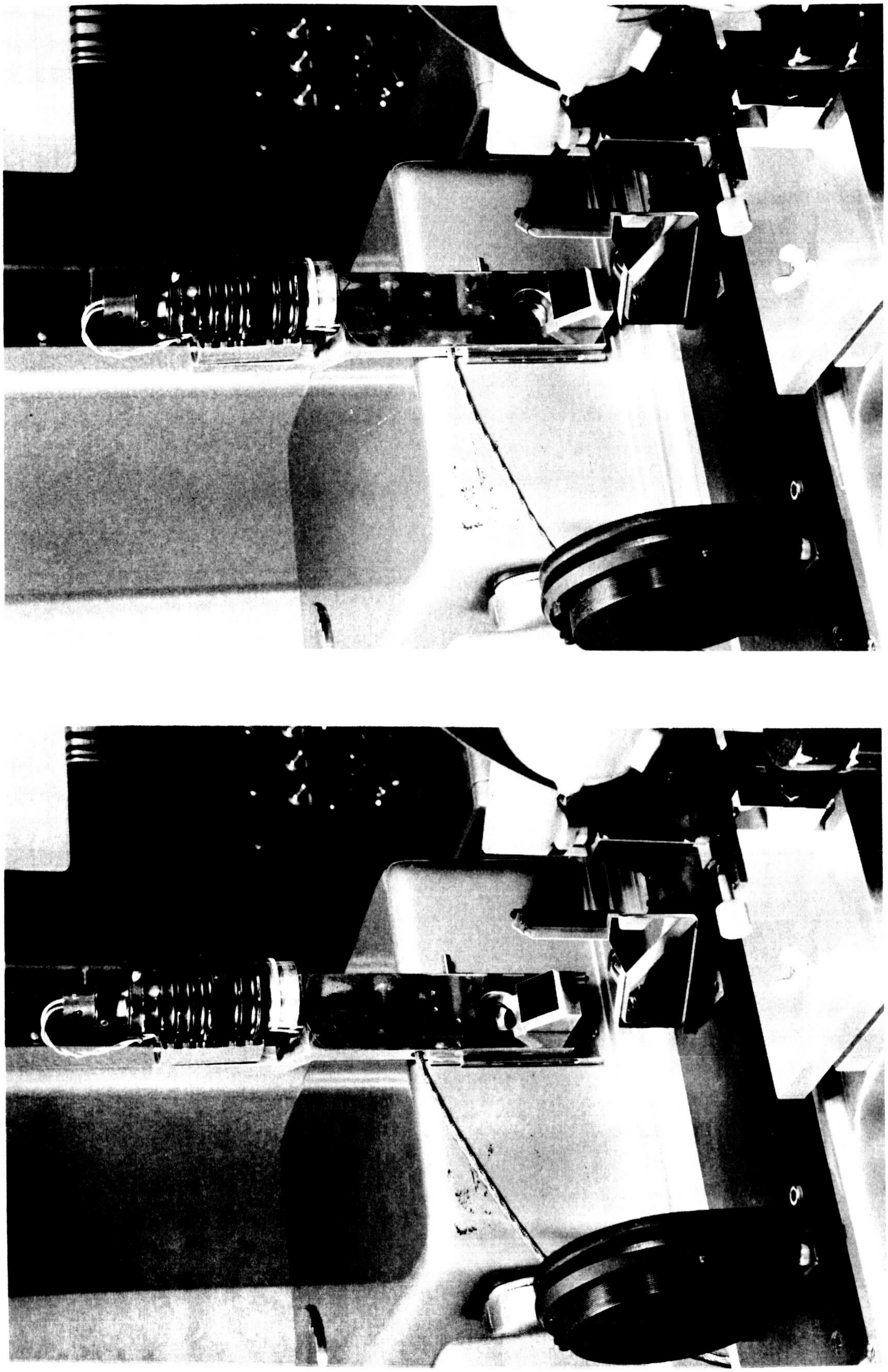


APERTURE MICROSCOPE ASSEMBLY ON SPECTRAL NORMAL EMITTANCE RIG

LEFT: SPECIMEN ALIGNMENT POSITION

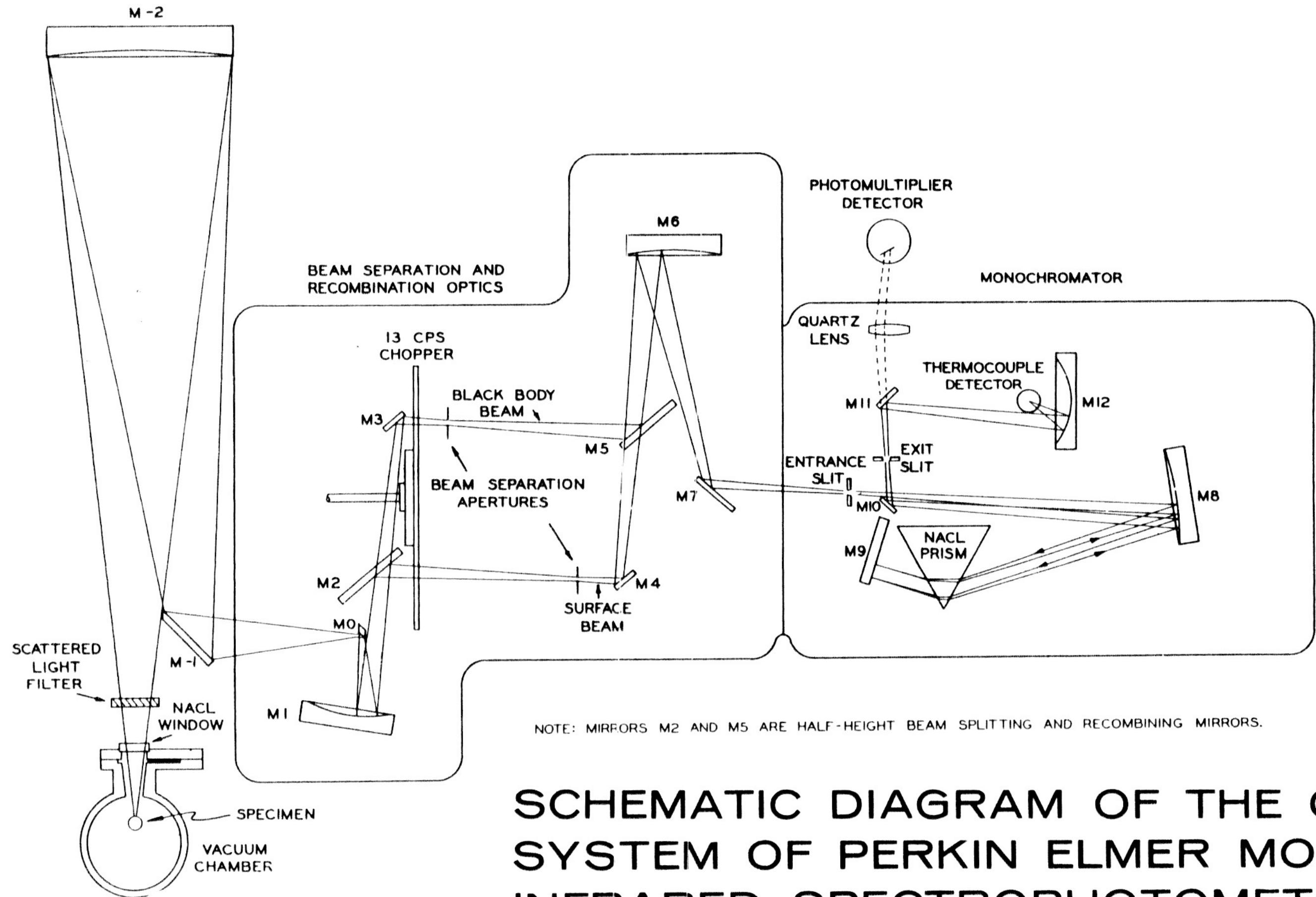
RIGHT: SPECTRAL EMITTANCE MEASUREMENT POSITION

Figure 9



ALIGNMENT LAMP ASSEMBLY ON SPECTRAL NORMAL EMITTANCE RIG
LEFT: SPECIMEN ALIGNMENT POSITION
RIGHT: SPECTRAL EMITTANCE MEASUREMENT POSITION

Figure 10

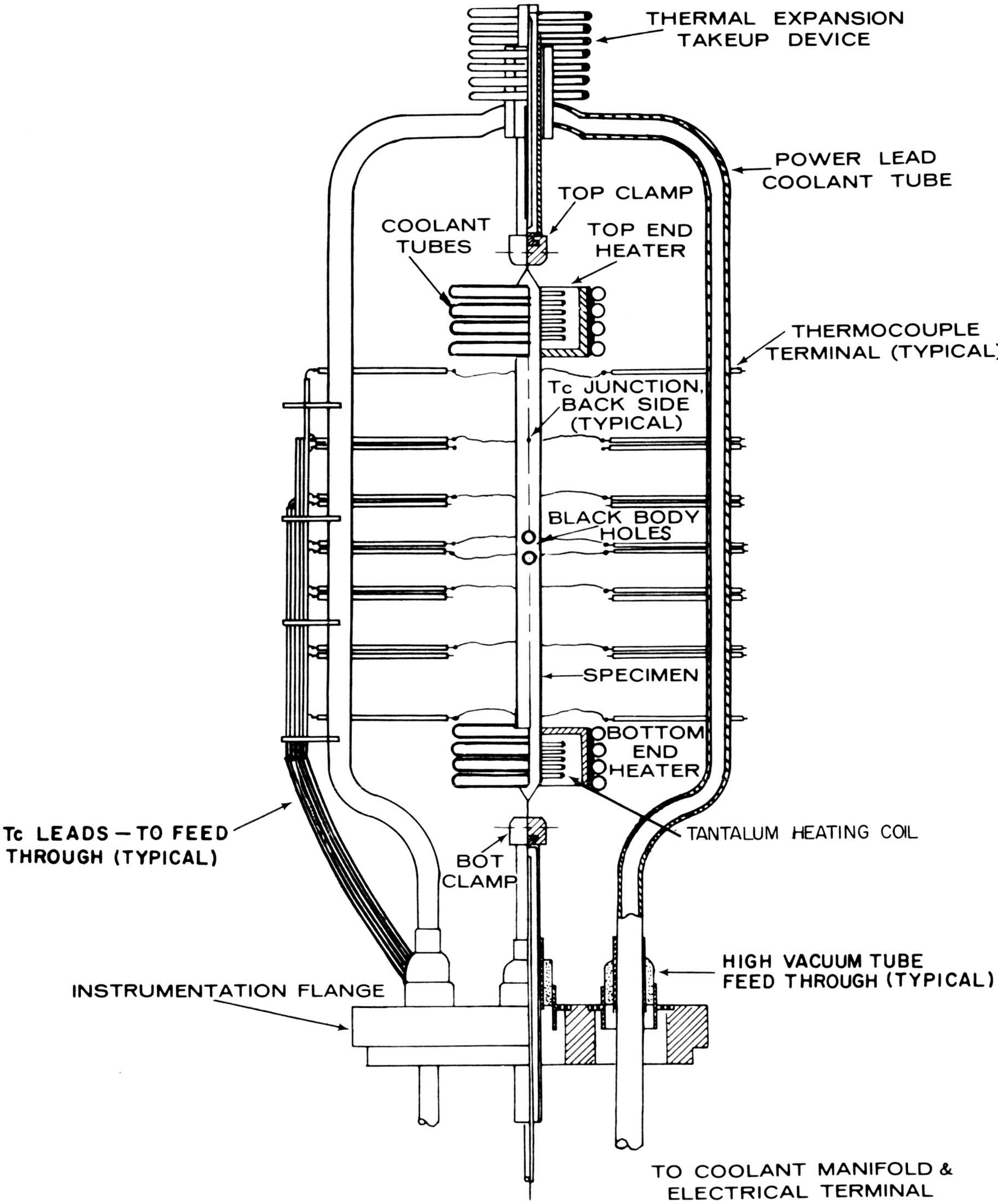


NOTE: MIRRORS M2 AND M5 ARE HALF-HEIGHT BEAM SPLITTING AND RECOMBINING MIRRORS.

SCHEMATIC DIAGRAM OF THE OPTICAL SYSTEM OF PERKIN ELMER MODEL 13U INFRARED SPECTROPHOTOMETER ADAPTED FOR MEASUREMENTS OF SPECTRAL EMITTANCE

Figure 11

INSTRUMENTATION FLANGE OF NEW TOTAL HEMISPHERICAL EMITTANCE RIG



CIRCULAR TUBULAR EMITTANCE TEST SPECIMEN SHOWING THERMOCOUPLE LOCATIONS

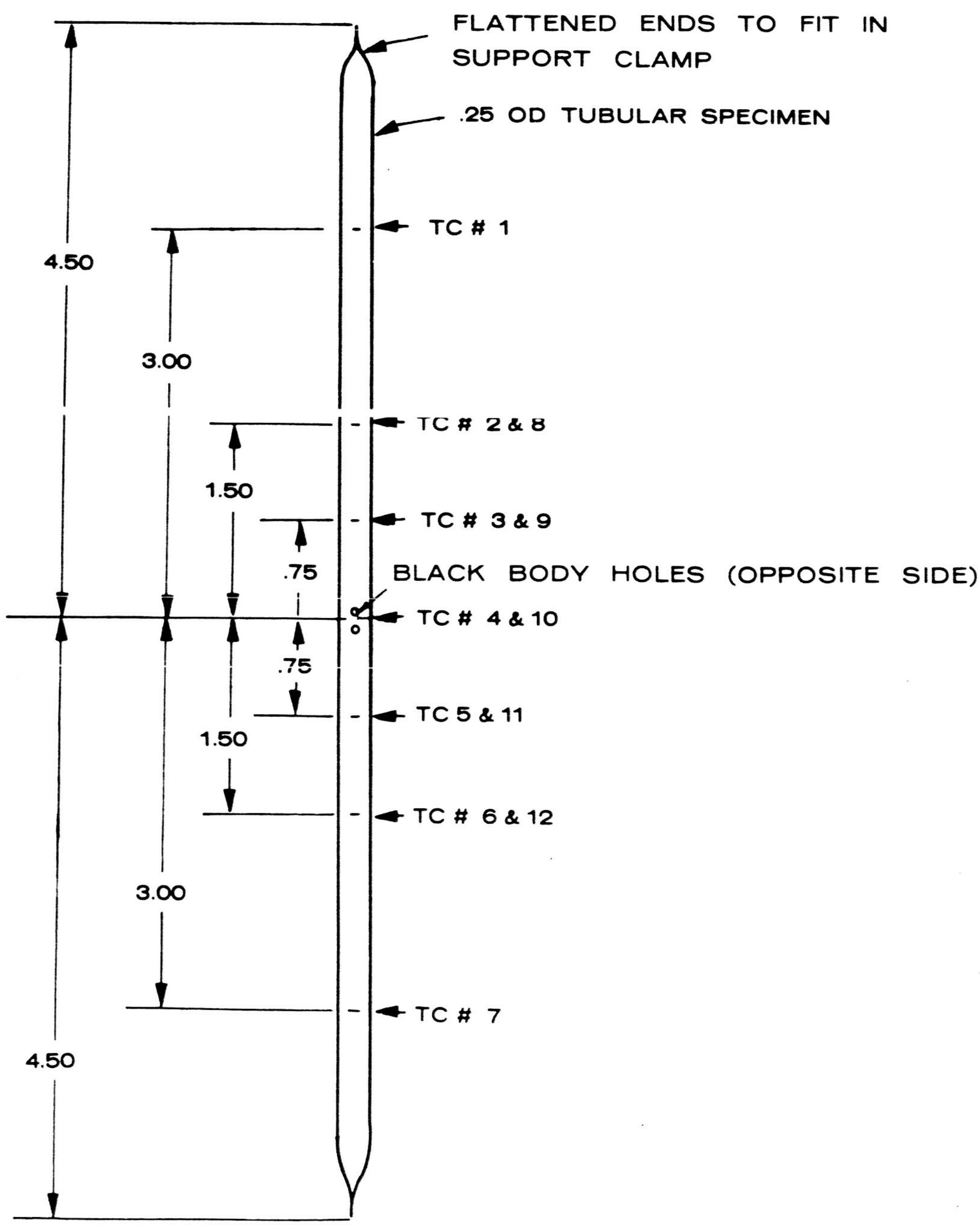
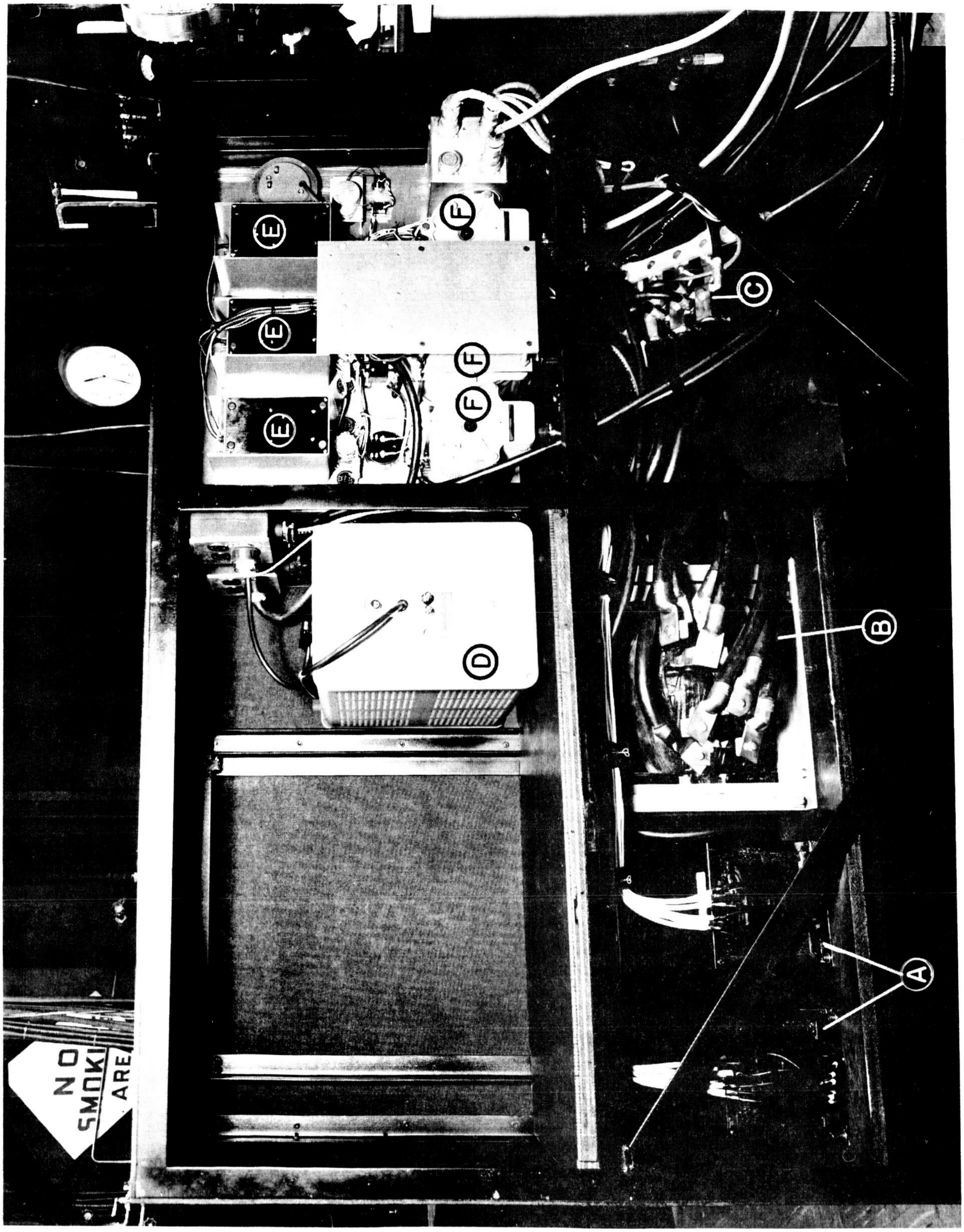


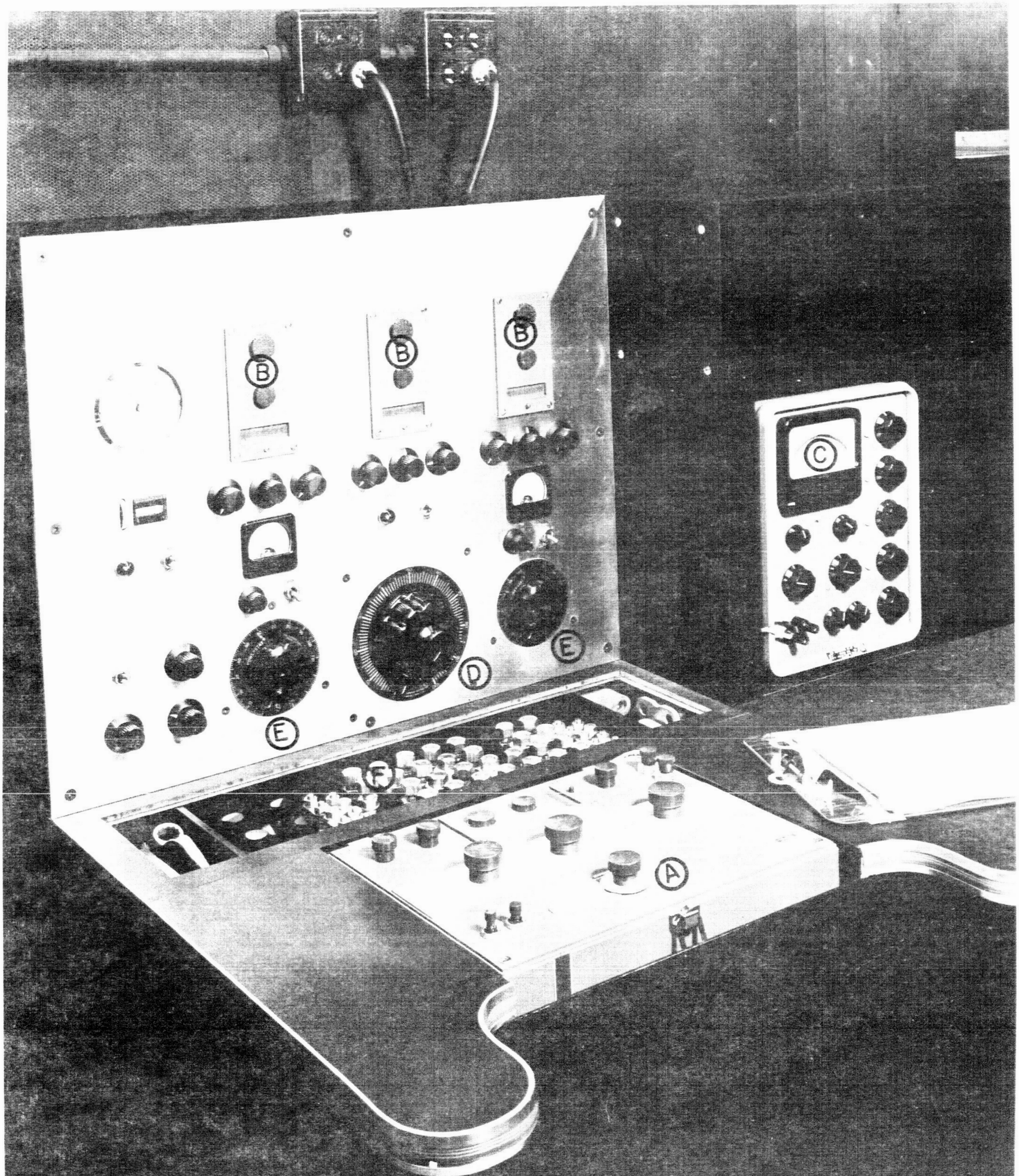
Figure 13



REAR OF CONTROL AND INSTRUMENTATION CONSOLE FOR NEW TOTAL HEMISPHERICAL EMITTANCE RIG

A. END HEATER TRANSFORMERS
B. SPECIMEN HEATING TRANSFORMER
C. SHUNT PANEL
D. VOLTMETER
E. GALVANOMETERS
F. POWERSTATS

Figure 14



CONTROL AND INSTRUMENTATION CONSOLE FOR NEW TOTAL HEMI-SPHERICAL EMITTANCE RIG

A. SLIDE WIRE MILLIVOLT POTENTIOMETER

B. GALVANOMETERS

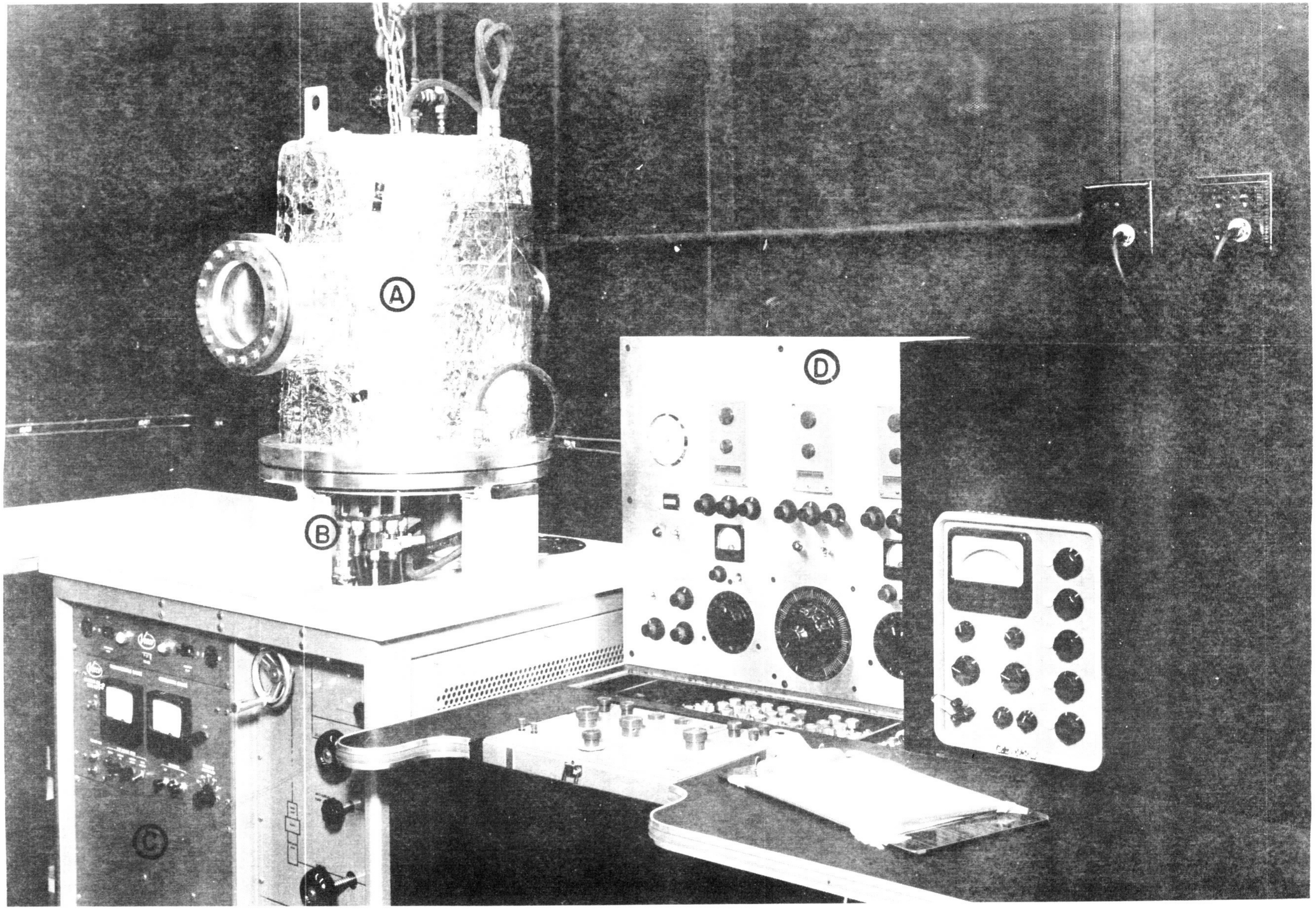
C. AC-DC DIFFERENTIAL VOLTMETER

D. SPECIMEN HEATING POWERSTAT

E. END HEATER POWERSTATS

F. LINK SWITCH PANEL

Figure 15



NEW TOTAL HEMISPHERICAL EMITTANCE RIG AND ASSOCIATED EQUIPMENT
A. VACUUM CHAMBER
B. INSTRUMENTATION FLANGE
C. EVACUATION EQUIPMENT
D. CONTROL AND INSTRUMENTATION CONSOLE

Figure 16

BLOCK DIAGRAM OF INSTRUMENTATION FOR NEW TOTAL HEMISPHERICAL EMITTANCE RIG

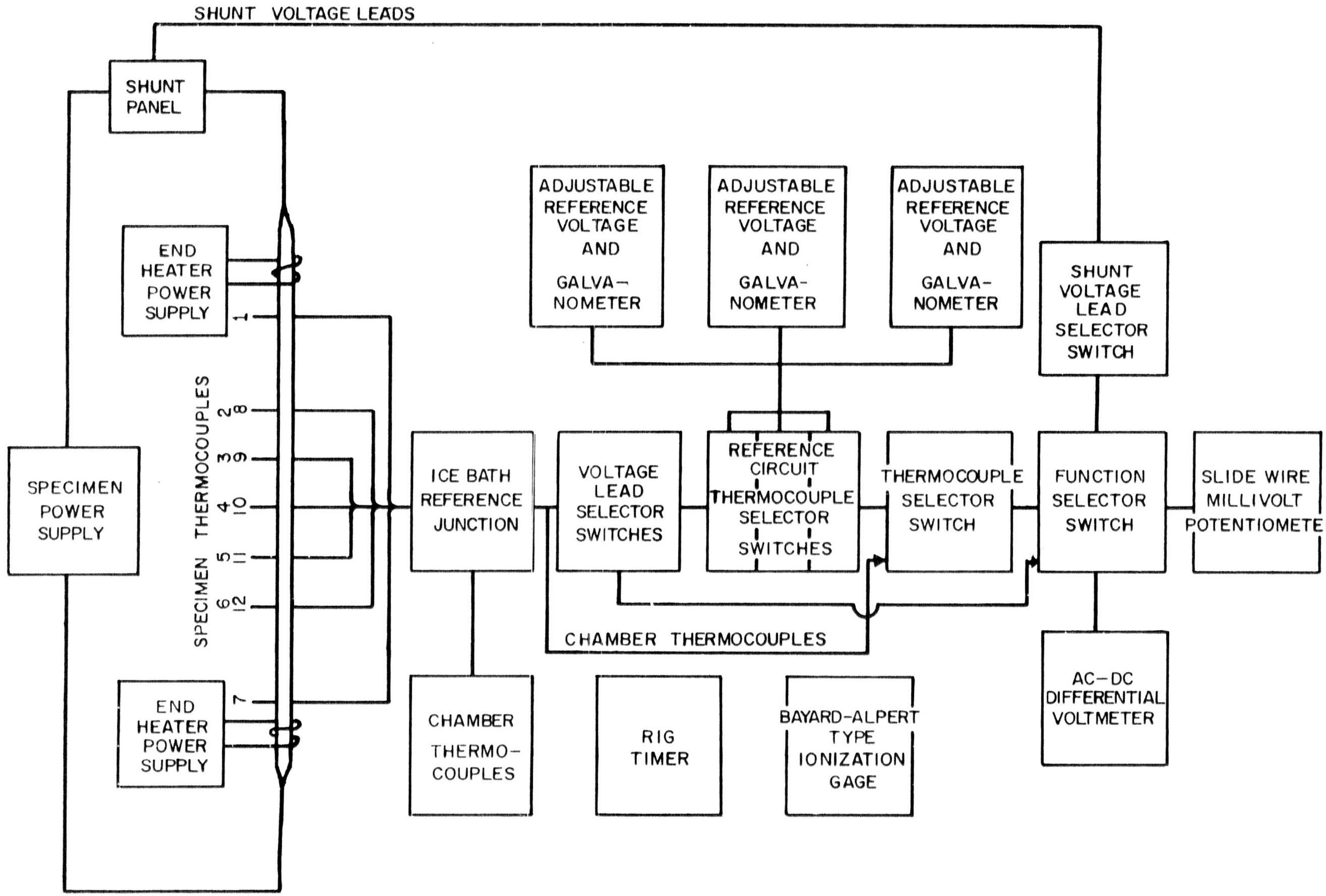
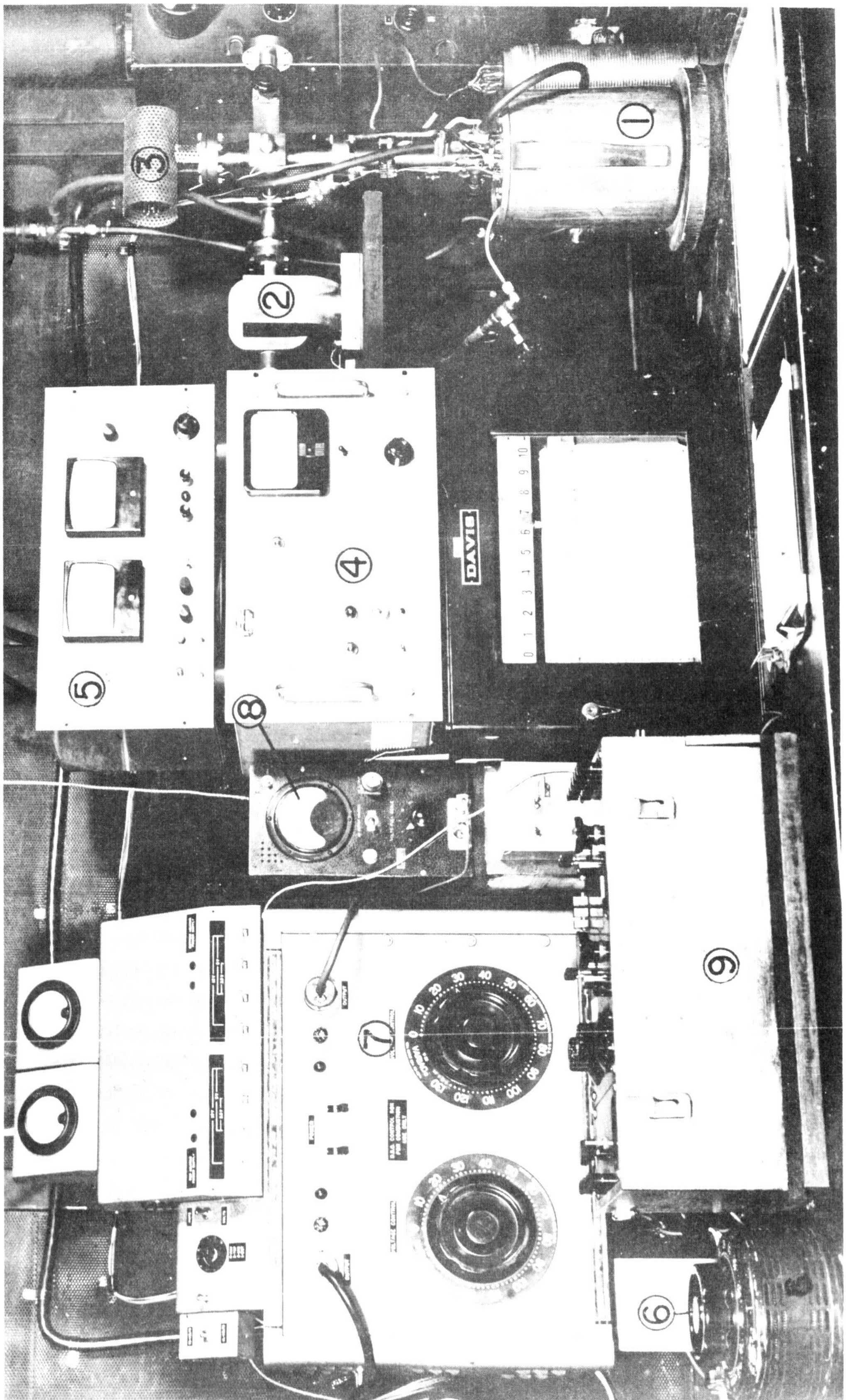


Figure 17



ORIGNIAL TOTAL EMITTANCE RIG AND ASSOCIATED EQUIPMENT

1- VACUUM CHAMBER AND COOLING BATH
2- ION GETTERING PUMP
3- IONIZATION GAGE
4- PUMP POWER SUPPLY
5- POWER SUPPLY FOR IONIZATION GAGE
6- POWER SUPPLY FOR HEATING SPECIMEN
7- POWER SUPPLIES FOR END HEATERS
8- VOLTAGE AND CURRENT METER
9- POTENTIOMETER

SECTIONED DRAWING OF ORIGINAL TOTAL HEMISPHERICAL EMITTANCE RIG SHOWING THE RELATIVE LOCATION OF SPECIMEN & RIG DETAIL

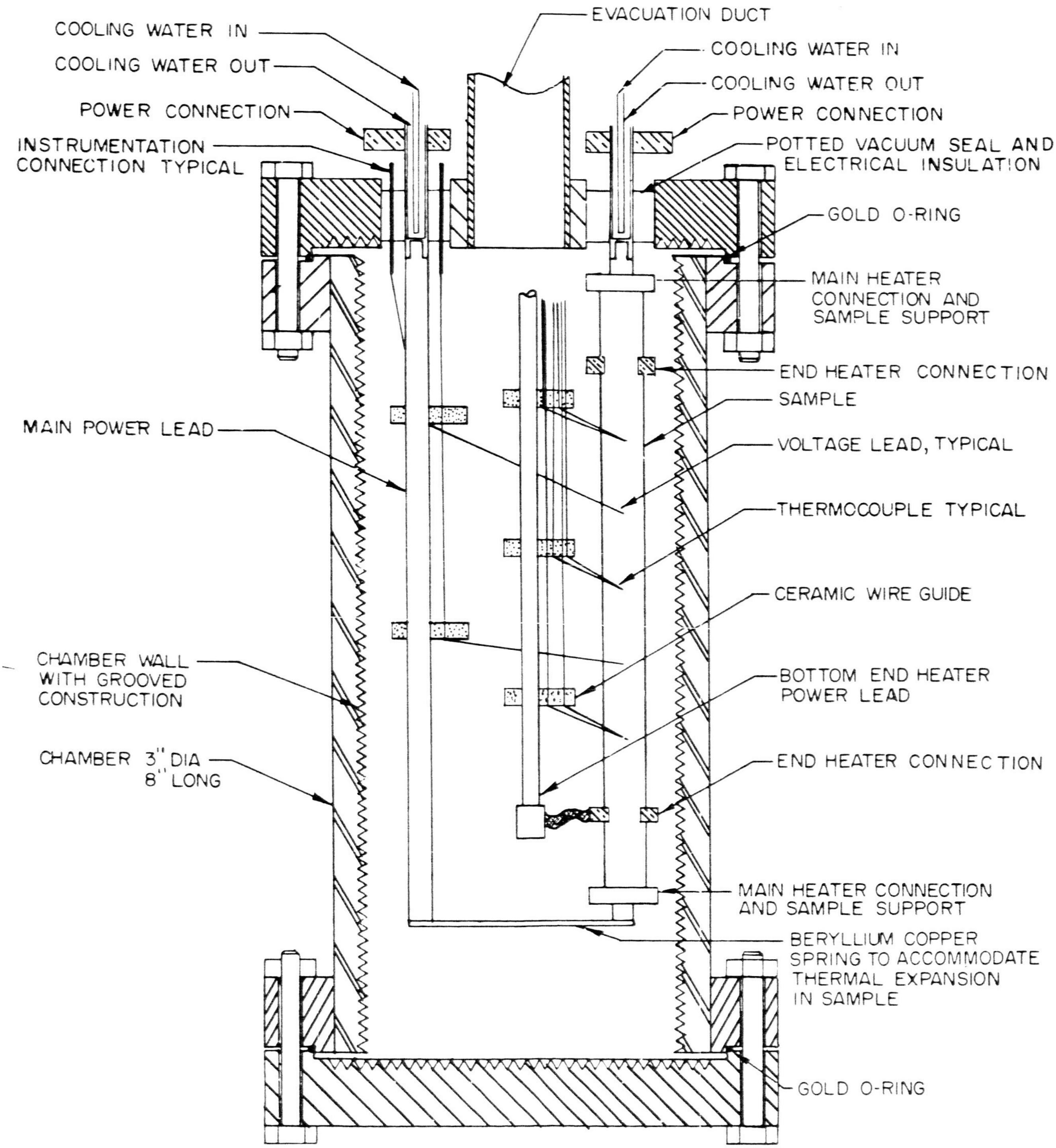


Figure 19

BLOCK DIAGRAM VACUUM SYSTEM & POWER SUPPLIES FOR ORIGINAL TOTAL HEMISPHERICAL EMITTANCE RIG

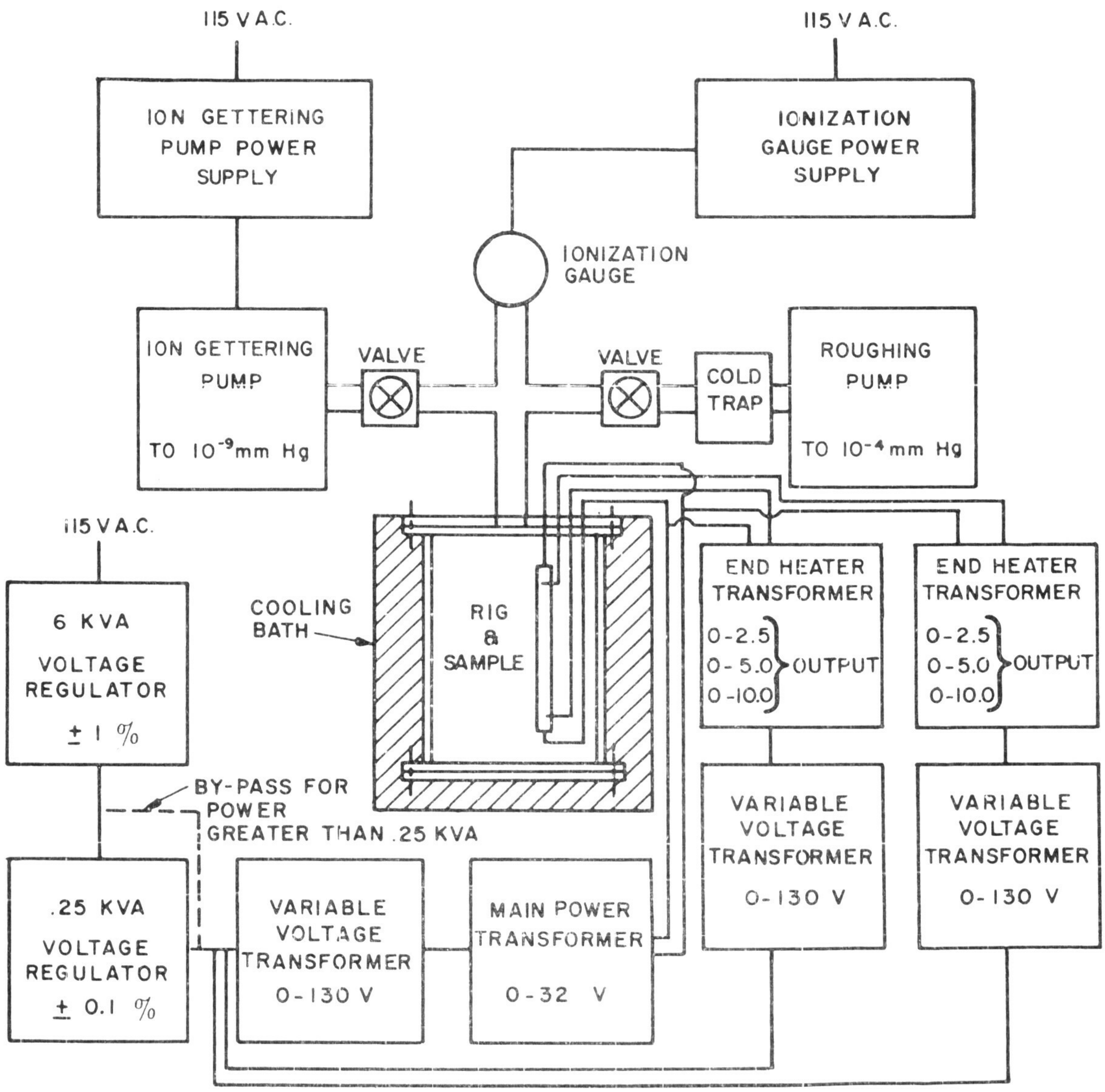
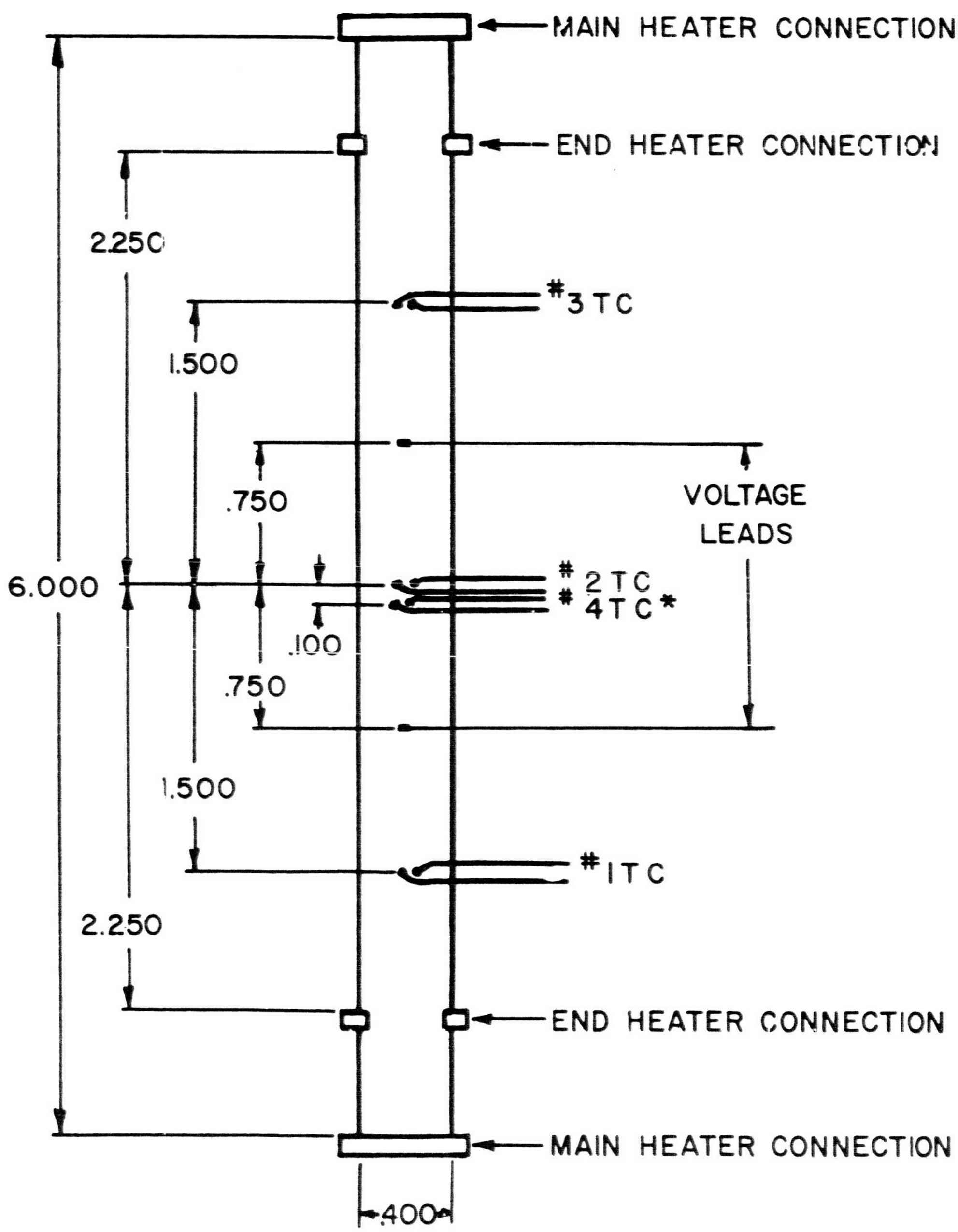


Figure 20

TEST SPECIMEN GEOMETRY & INSTRUMENTATION ARRANGEMENT OF ORIGINAL TOTAL HEMISPHERICAL EMITTANCE & SHORT TERM ENDURANCE RIGS



*USED ONLY IN TOTAL HEMISPHERICAL EMITTANCE RIG

BLOCK DIAGRAM
OF ORIGINAL TOTAL HEMISPHERICAL
RIG INSTRUMENTATION

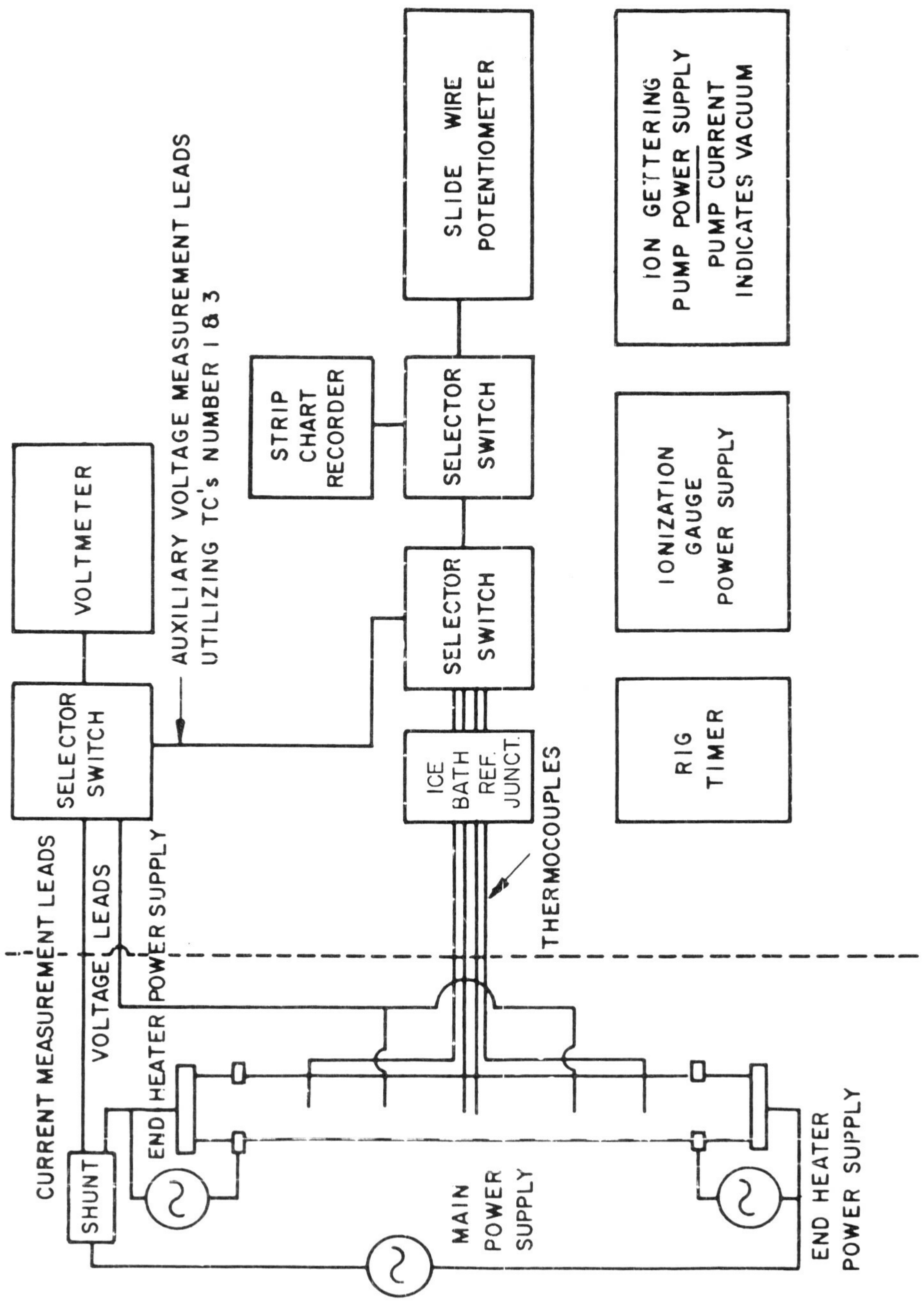
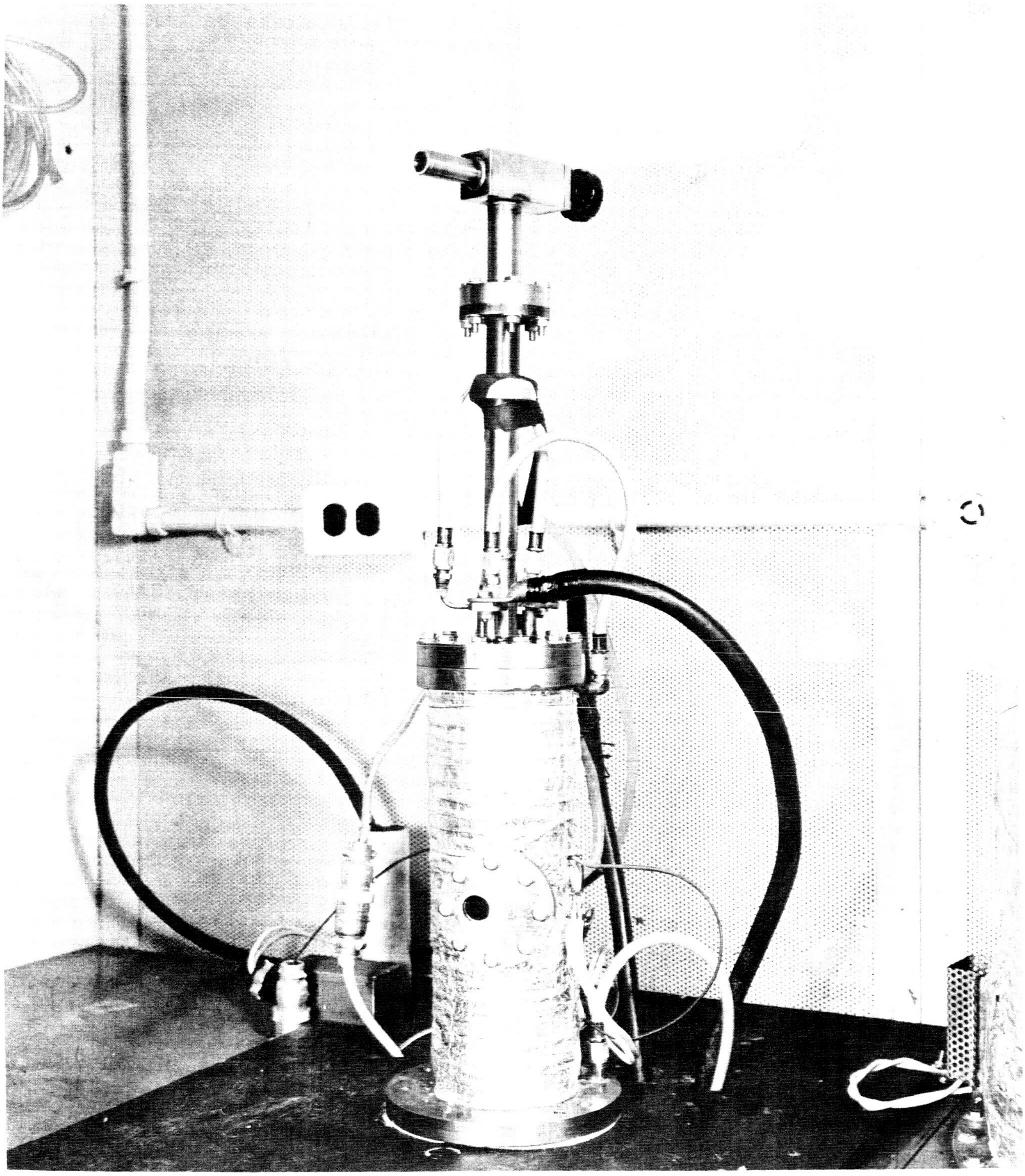


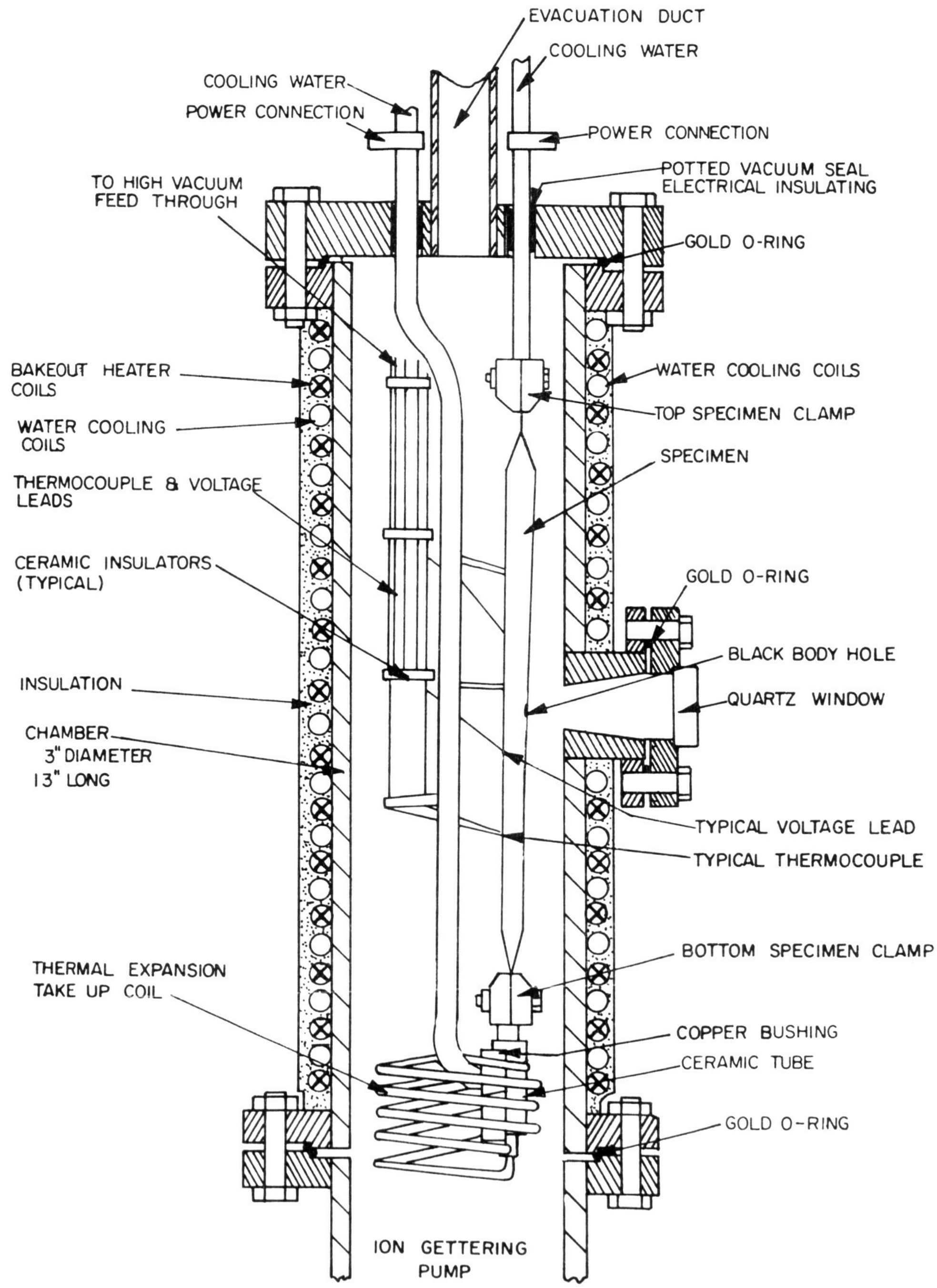
Figure 22

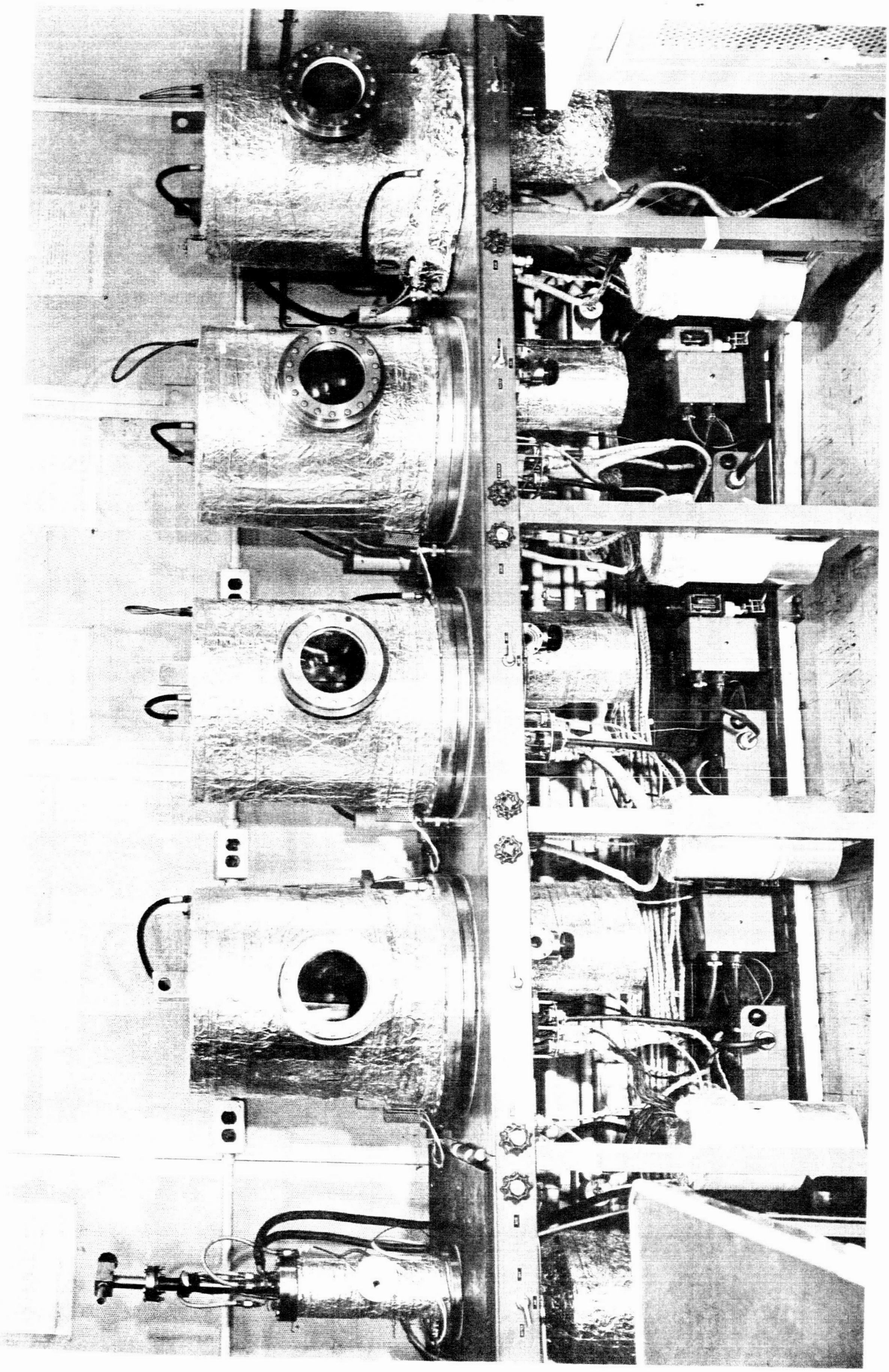


SHORT TERM ENDURANCE RIG SHOWING THE ASSEMBLED VACUUM CHAMBER

Figure 23

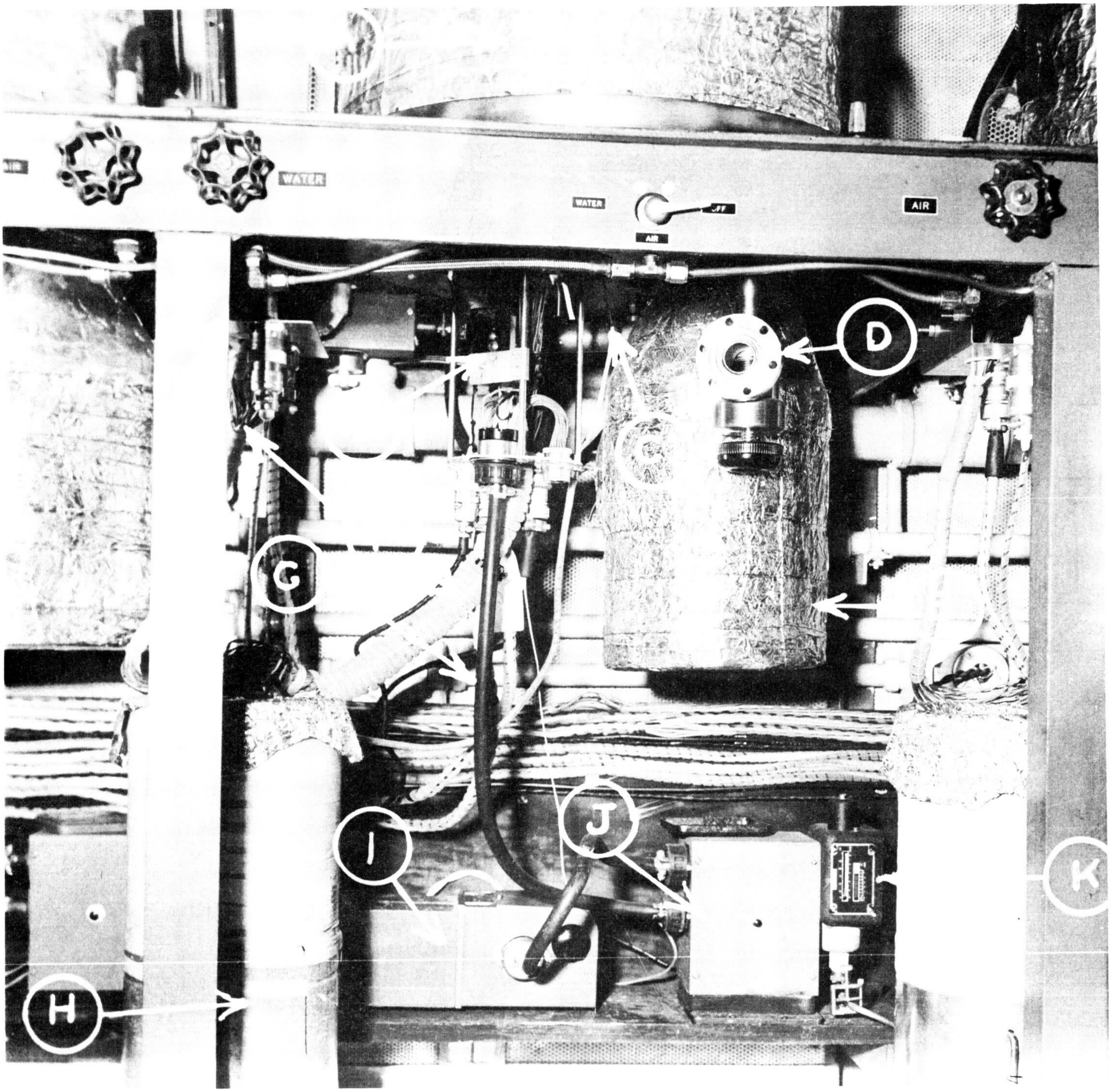
SKETCH OF THE SHORT TERM ENDURANCE RIG SHOWING THE RELATIVE LOCATION OF SPECIMEN AND RIG DETAIL





SHORT AND LONG TERM ENDURANCE RIGS

Figure 25



TYPICAL INSTRUMENTATION AND ACCESSORY EQUIPMENT FOR LONG TERM ENDURANCE RIGS

A- LOWER PORTION OF VACUUM CHAMBER
B- CURRENT SHUNT
C- POWER CABLE TO VACION PUMP
D- ATTACHMENT FOR ROUGHING PUMP
E- VACION PUMP
F- T-C LEADS TO ICE BATH
G- POWER CABLE TO SPECIMEN HEATER
H- ICE BATH
I- ISOLATION TRANSFORMER
J- ELECTROMAGNETIC RELAY (MANUAL RESET SWITCH)
K-LOW WATER PRESSURE CUT-OFF RELAY

Figure 26

SECTIONED DRAWING OF INSTRUMENTATION FLANGE OF LONG TERM ENDURANCE RIGS WITH A SNAP-8 FIN SEGMENT INSTALLED

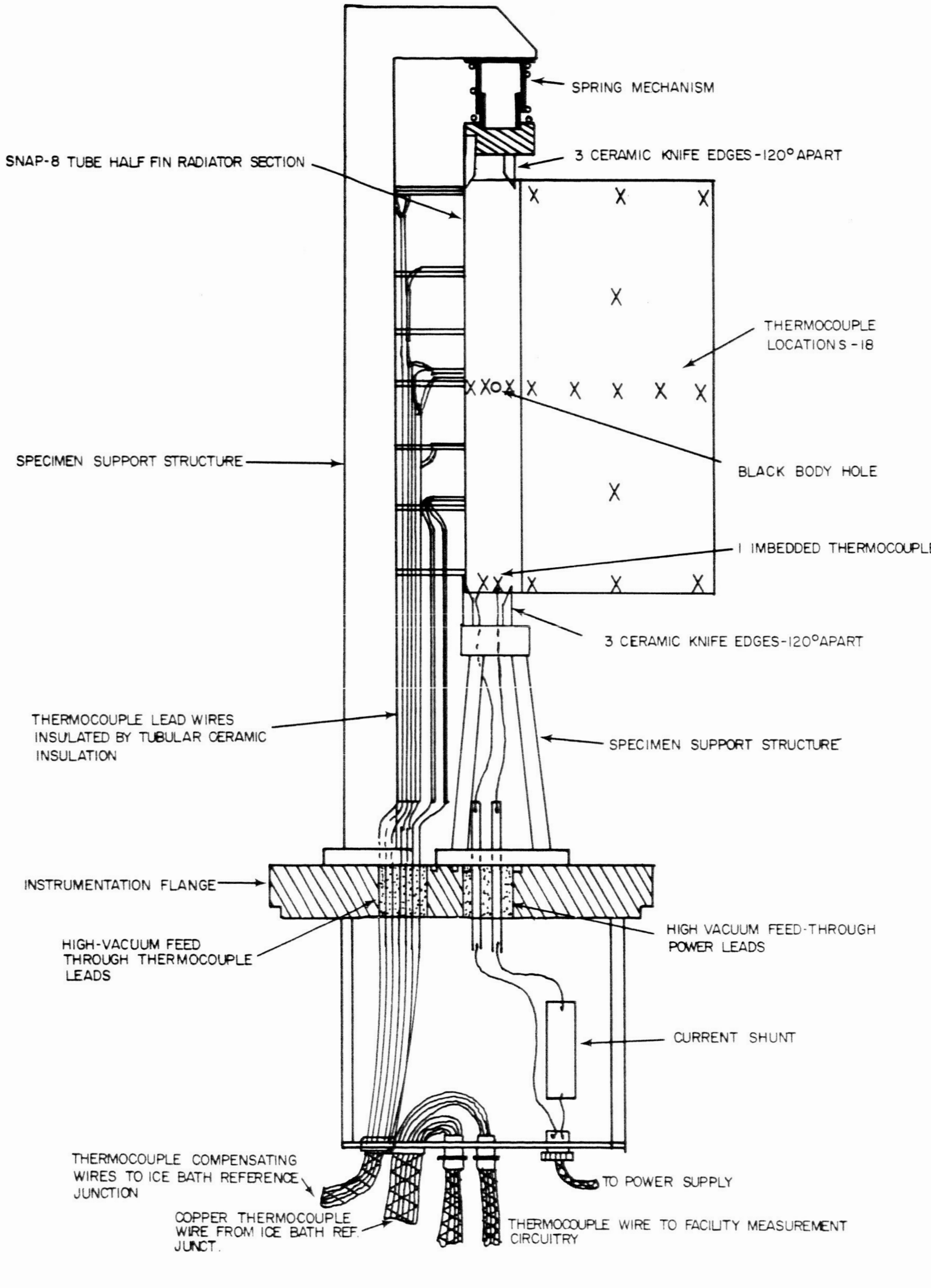
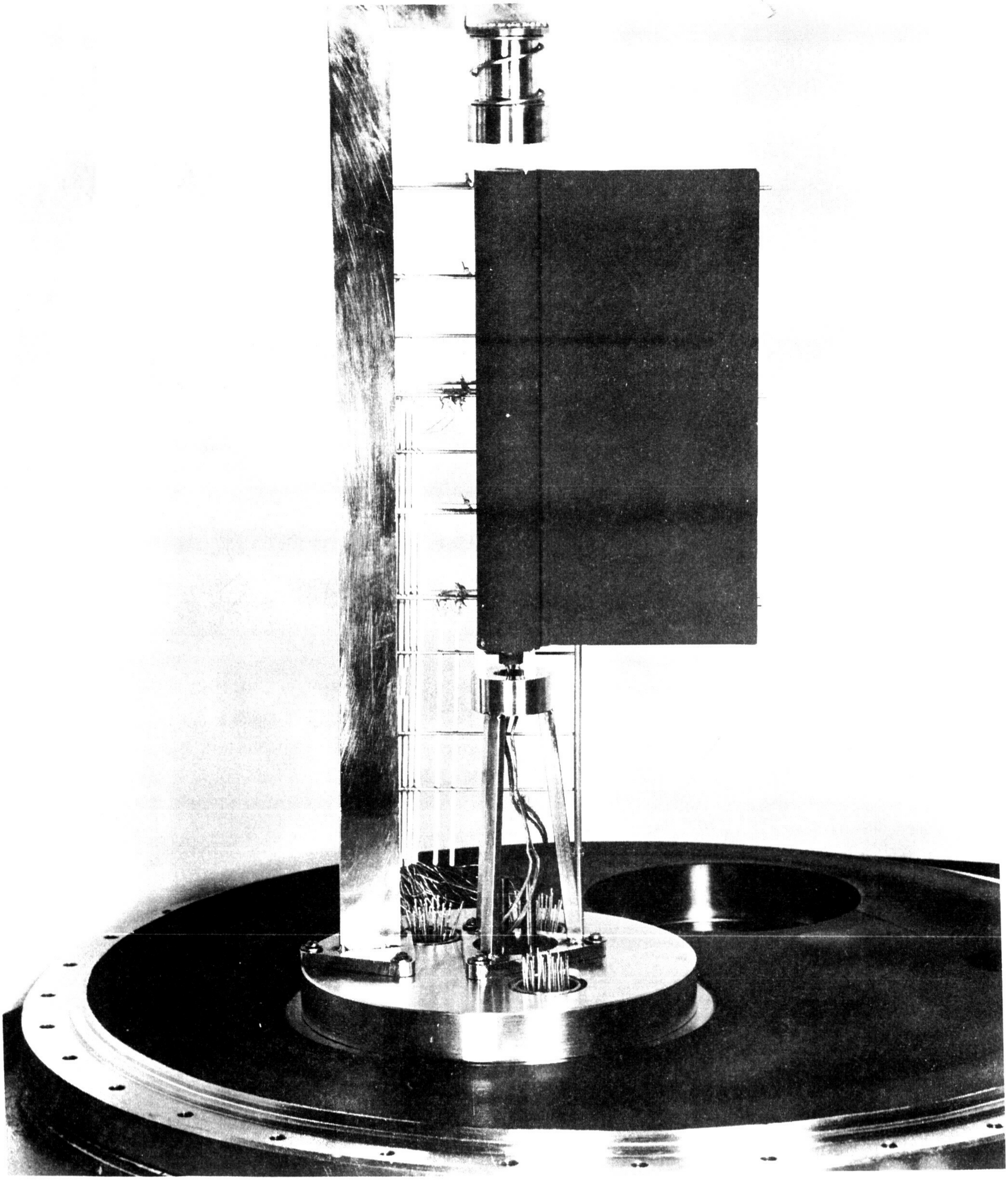


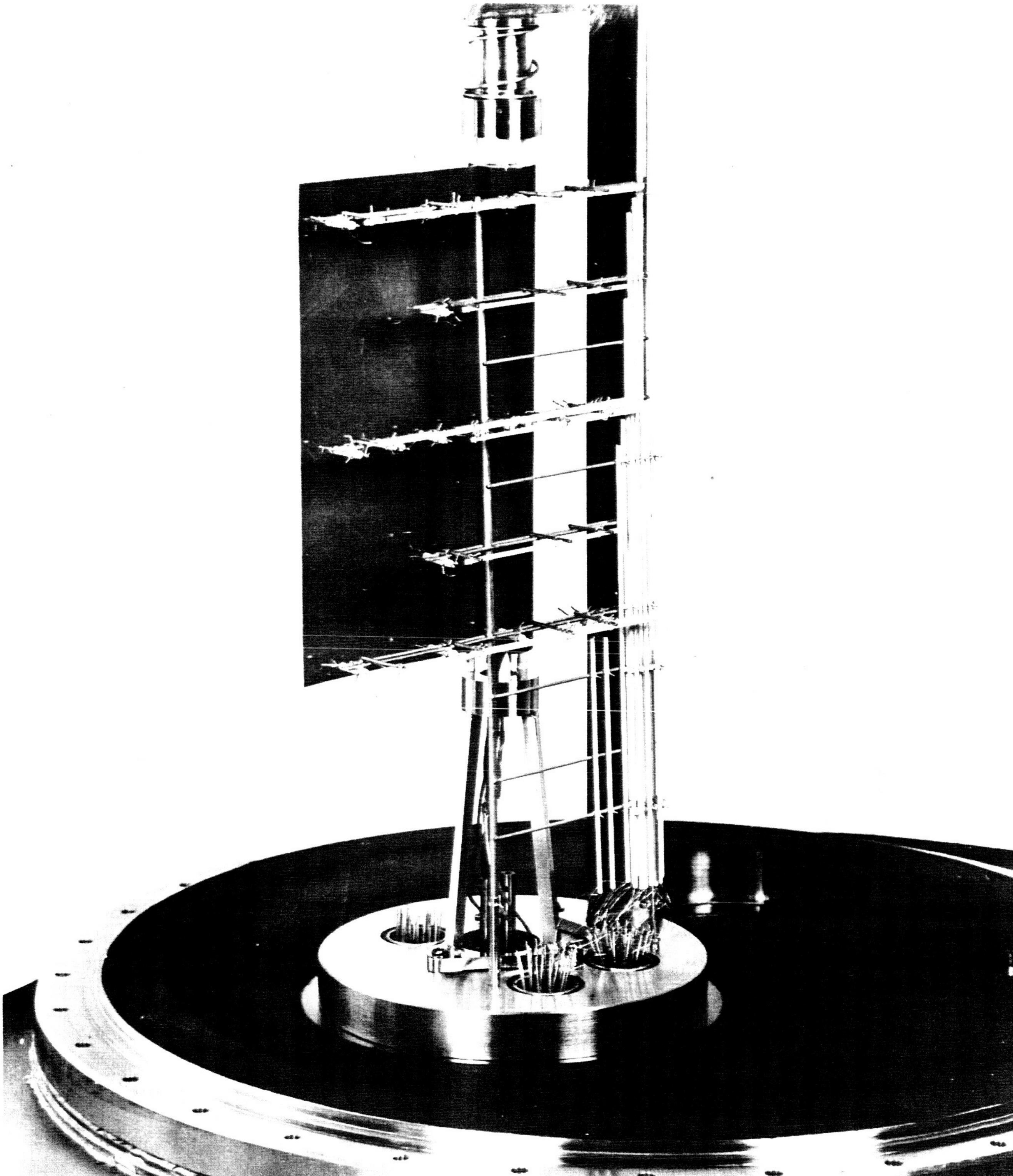
Figure 27



TYPICAL SNAP-8 FIN SEGMENT INSTRUMENTED WITH PLATINUM-PLATINUM 10% RHODIUM THERMOCOUPLES INSTALLED IN LONG TERM ENDURANCE RIG WITH VACUUM CHAMBER REMOVED

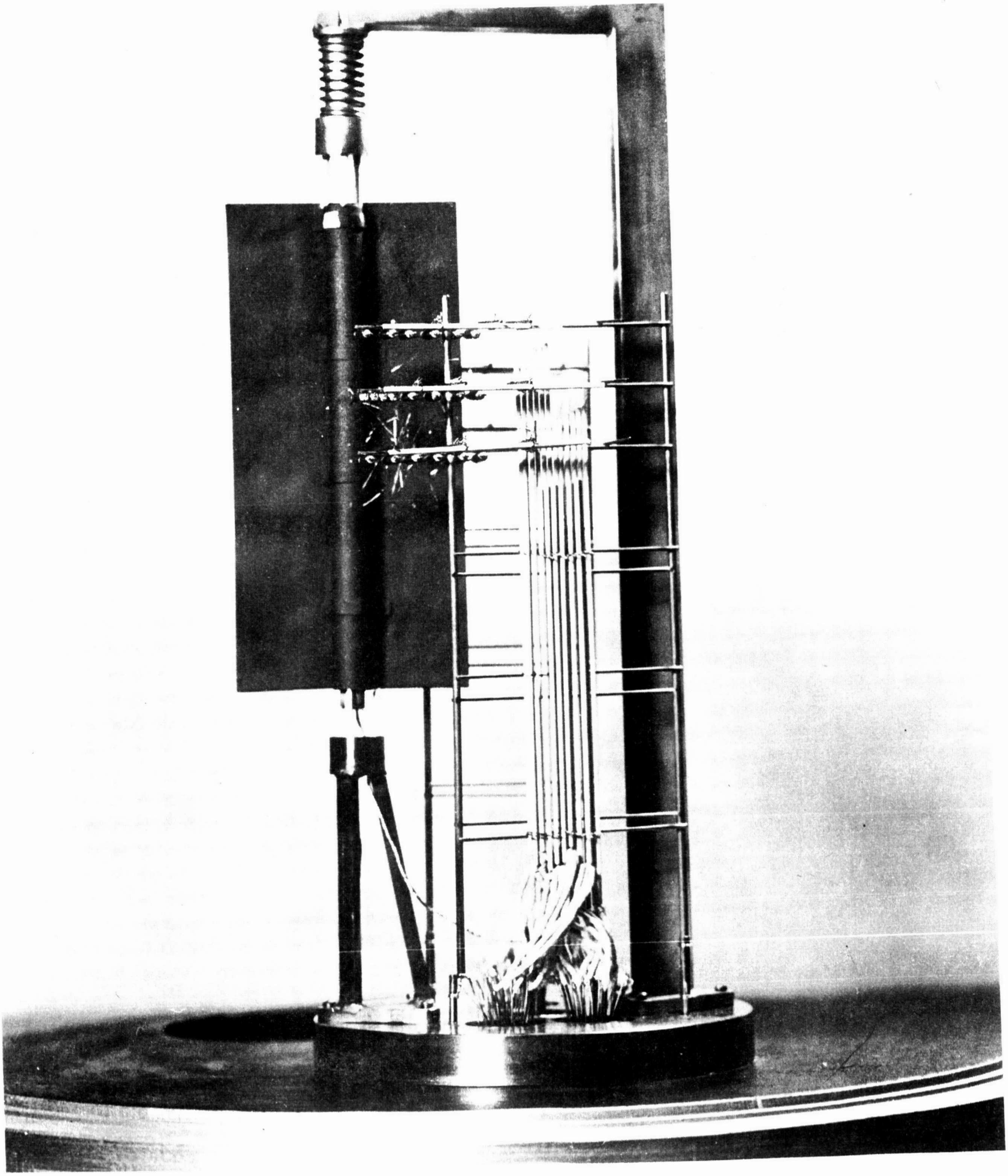
033

Figure 28



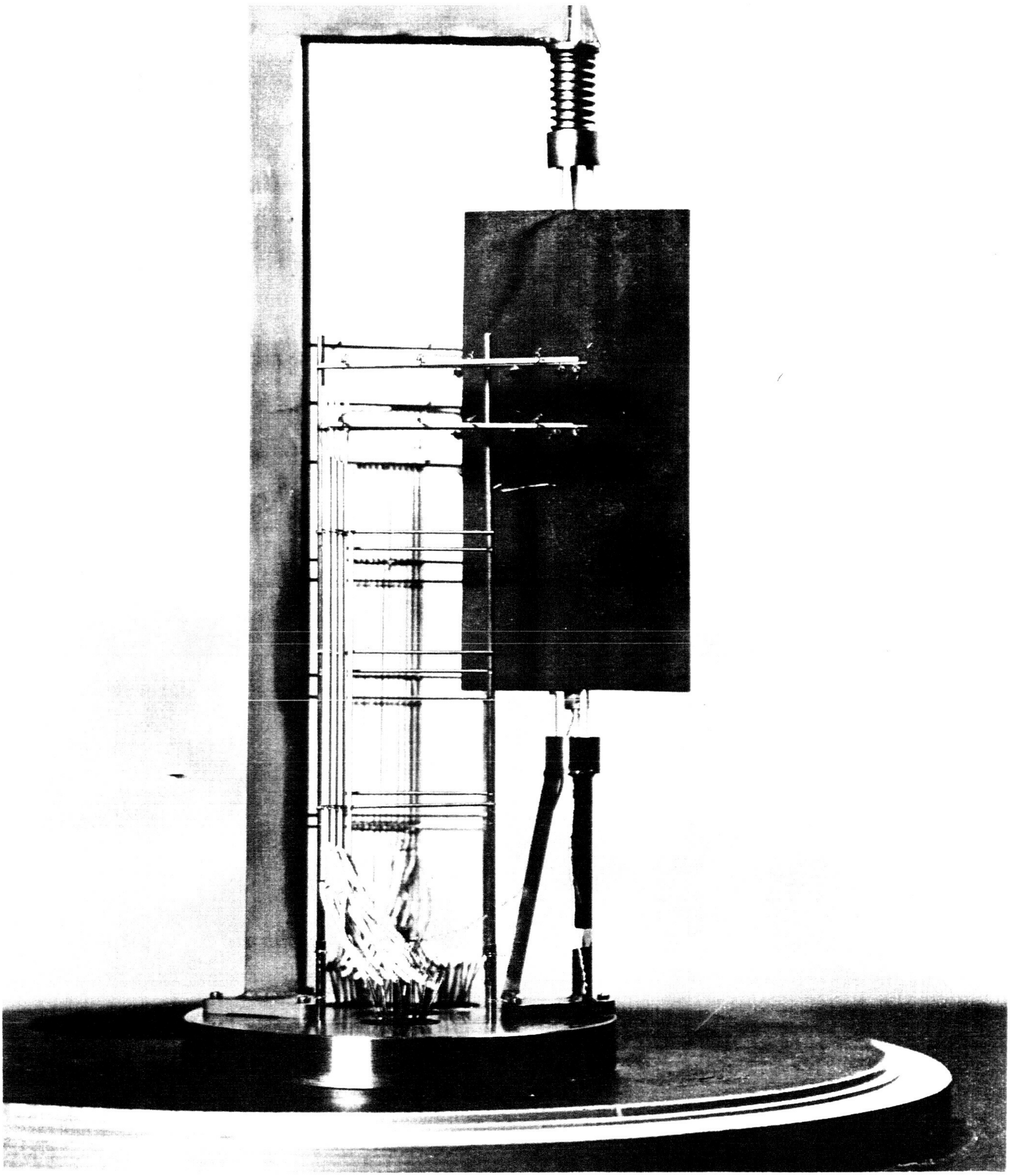
TYPICAL SNAP-8 FIN SEGMENT SHOWING PLATINUM-PLATINUM 10% RHODIUM THERMOCOUPLE SUPPORT ASSEMBLY

Figure 29



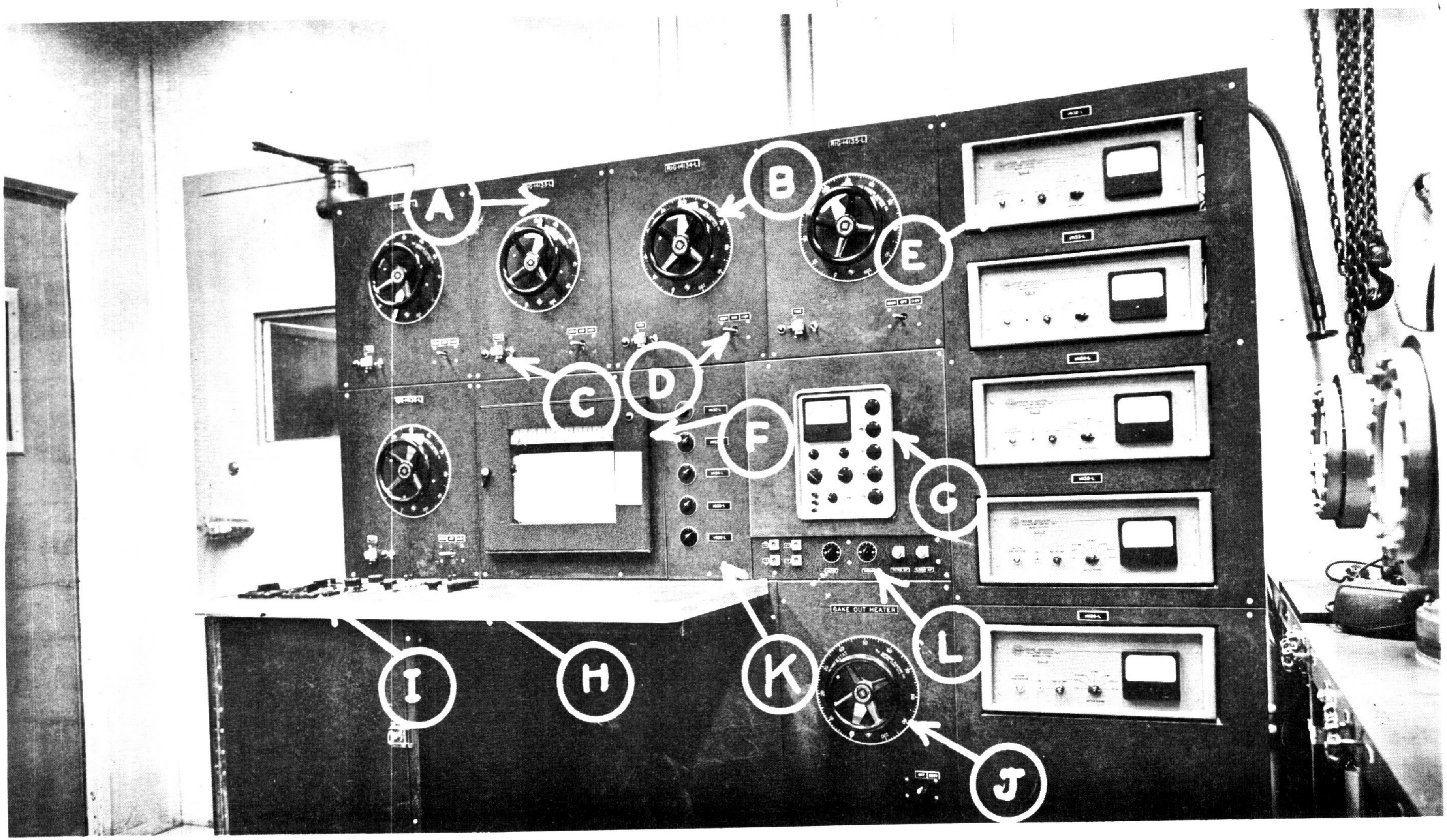
SUNFLOWER I FIN SEGMENT SHOWING PLATINUM-PLATINUM 10% RHODIUM THERMOCOUPLE SUPPORT ASSEMBLY ON TUBE SIDE OF SPECIMEN

Figure 30



SUNFLOWER I FIN SEGMENT SHOWING PLATINUM-PLATINUM 10% RHODIUM THERMOCOUPLE SUPPORT ASSEMBLY ON FLAT SIDE OF SPECIMEN

Figure 31



CONTOL AND INSTRUMENTATION CONSOLE FOR HIGH VACUUM ENDURANCE RIGS

A-RIG CONTROL PANEL, TYPICAL
B-RIG VOLTAGE CONTROL, TYPICAL
C-RIG TIMER, TYPICAL
D-VOLTAGE SWITCH, TYPICAL
E-VACUUM PUMP POWER SUPPLY, TYPICAL
F-FLIGHT RECORDER
G-FLUKE AC-DC DIFFERENTIAL VOLTMETER
H- L & N POTENTIOMETER
I- T-C SELECTOR SWITCH
J- BAKE OUT HEATER CONTROL
K- THERMOCOUPLE MEASUREMENT MODE SWITCH PANEL
L- SPECIMEN CURRENT & VOLTAGE MEASUREMENT SELECTION PANEL

Figure 32

BLOCK DIAGRAM OF INSTRUMENTATION & ACCESSORY EQUIPMENT FOR ENDURANCE RIGS

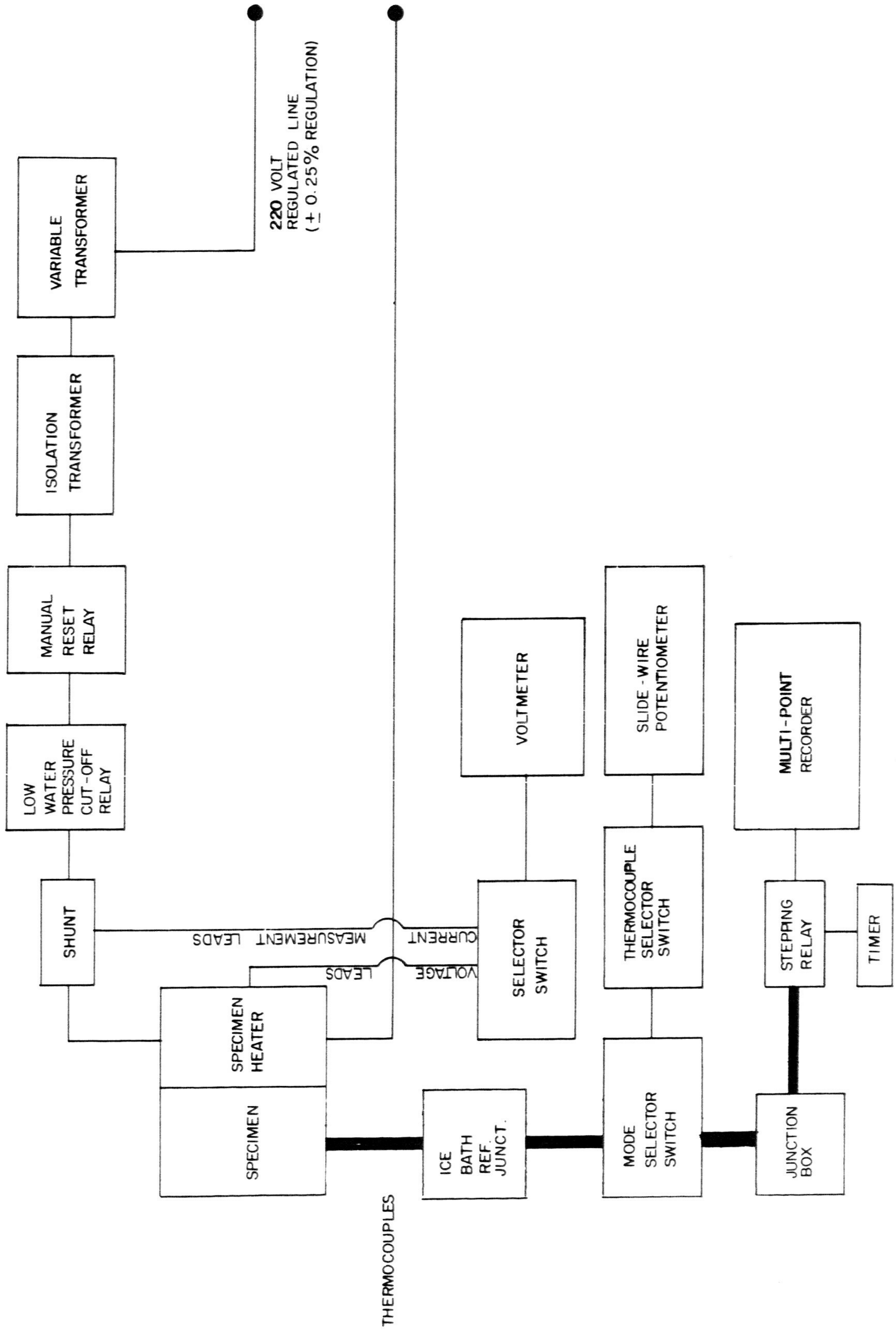
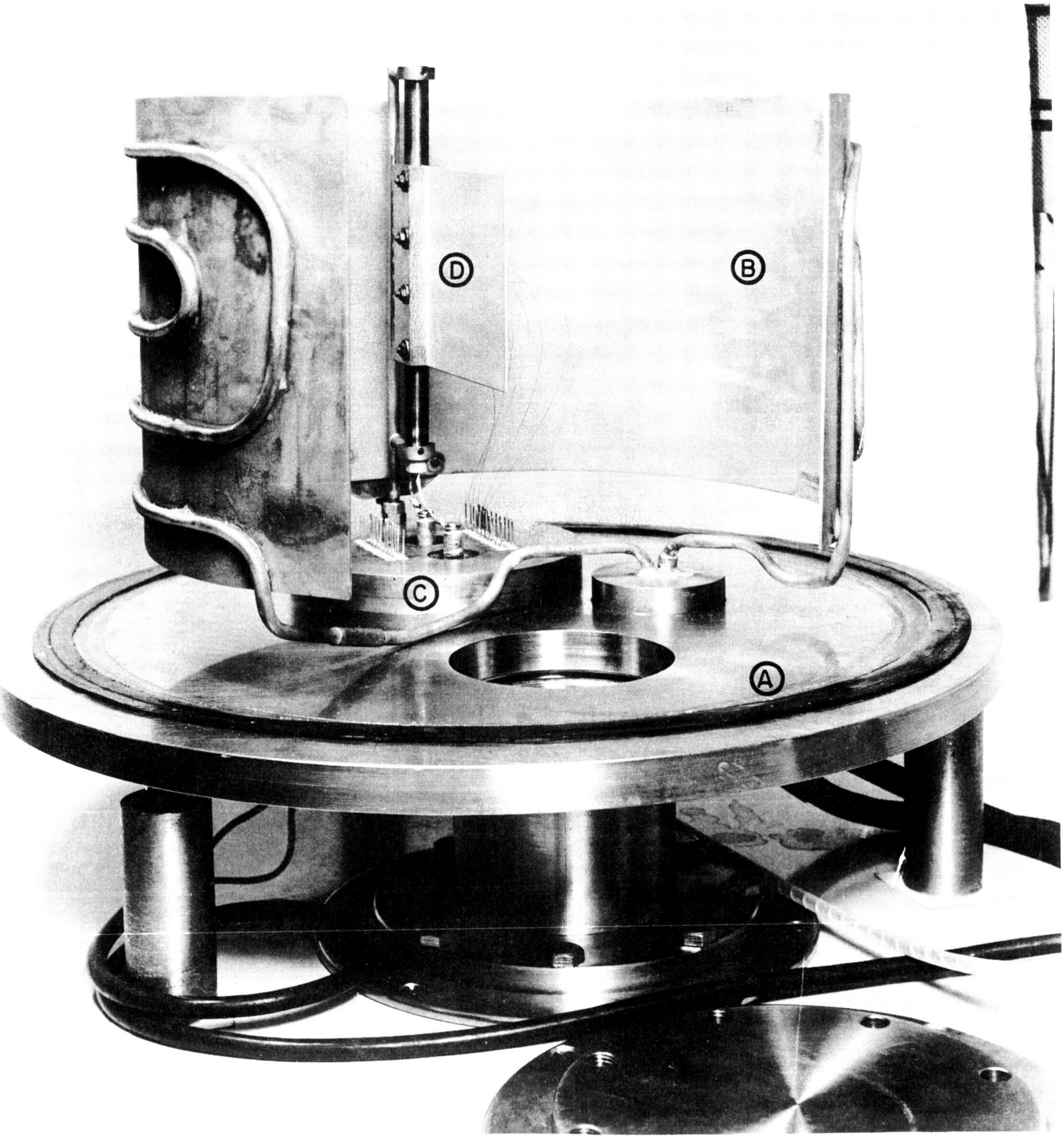


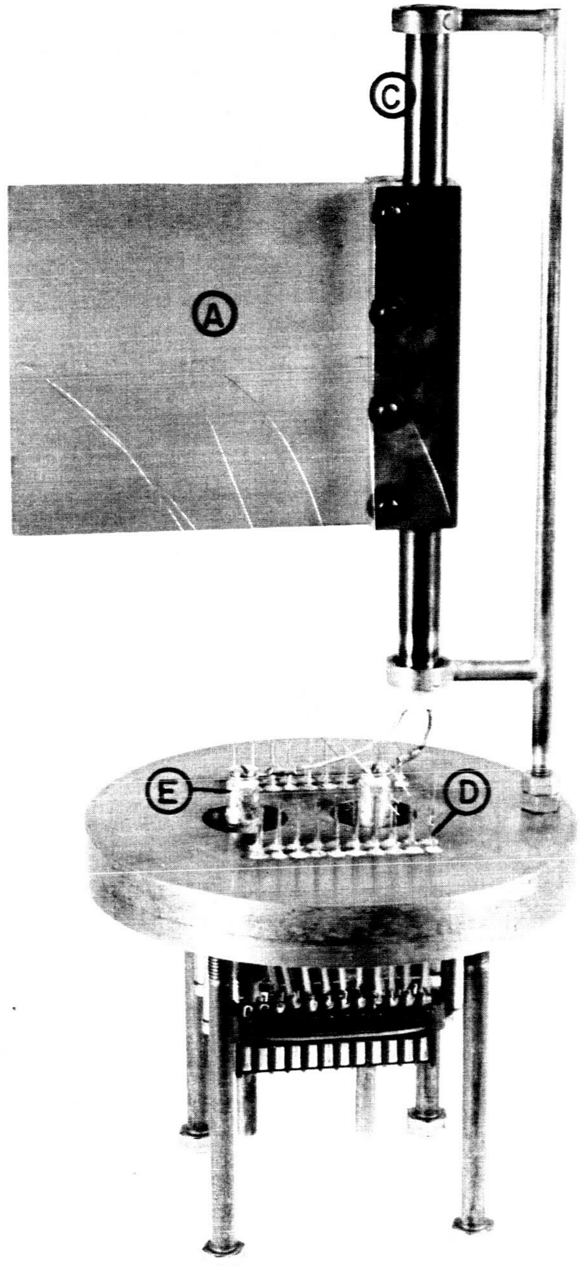
Figure 33



INSTRUMENTATION FLANGE INSTALLED ON BASE PLATE FOR ALUMINUM FIN THERMAL CYCLING RIG

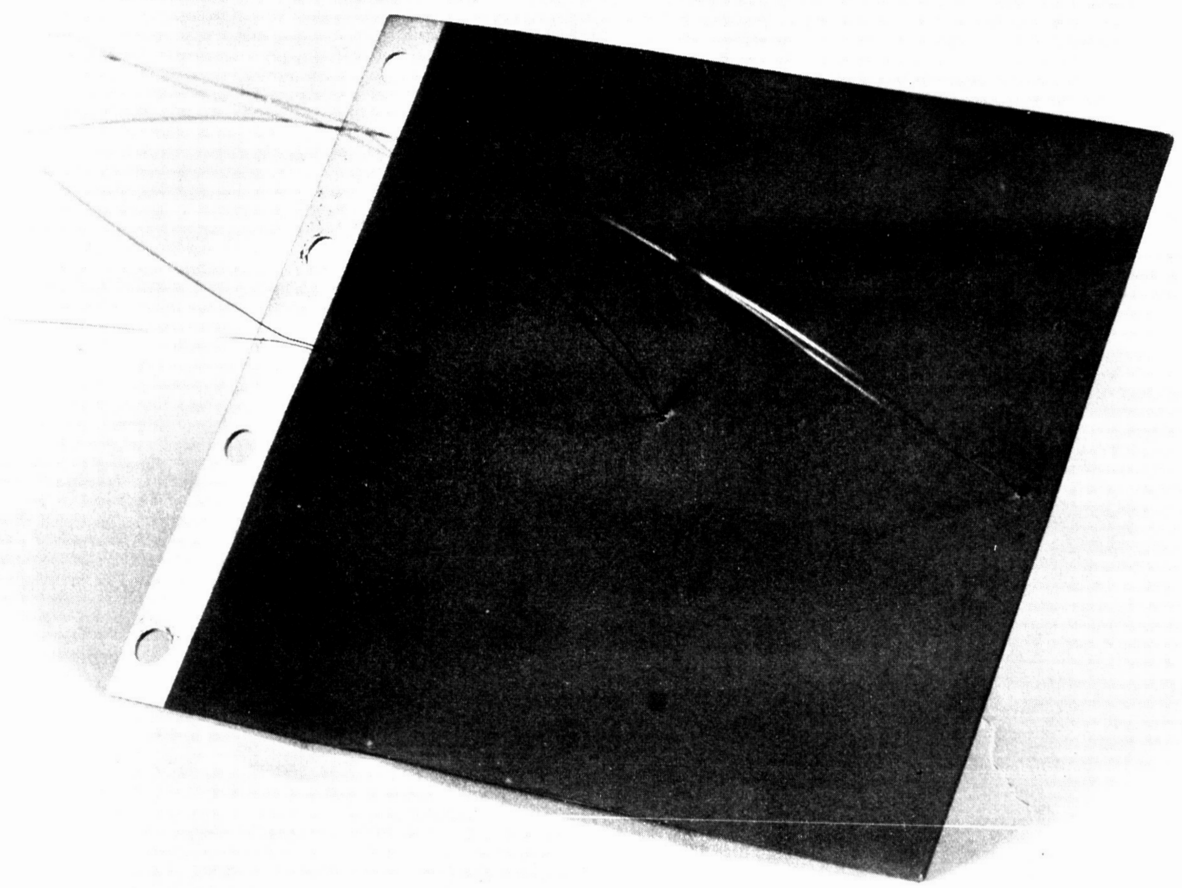
A. BASE PLATE
B. HEAT SHIELD
C. INSTRUMENTATION FLANGE
D. SPECIMEN

Figure 34



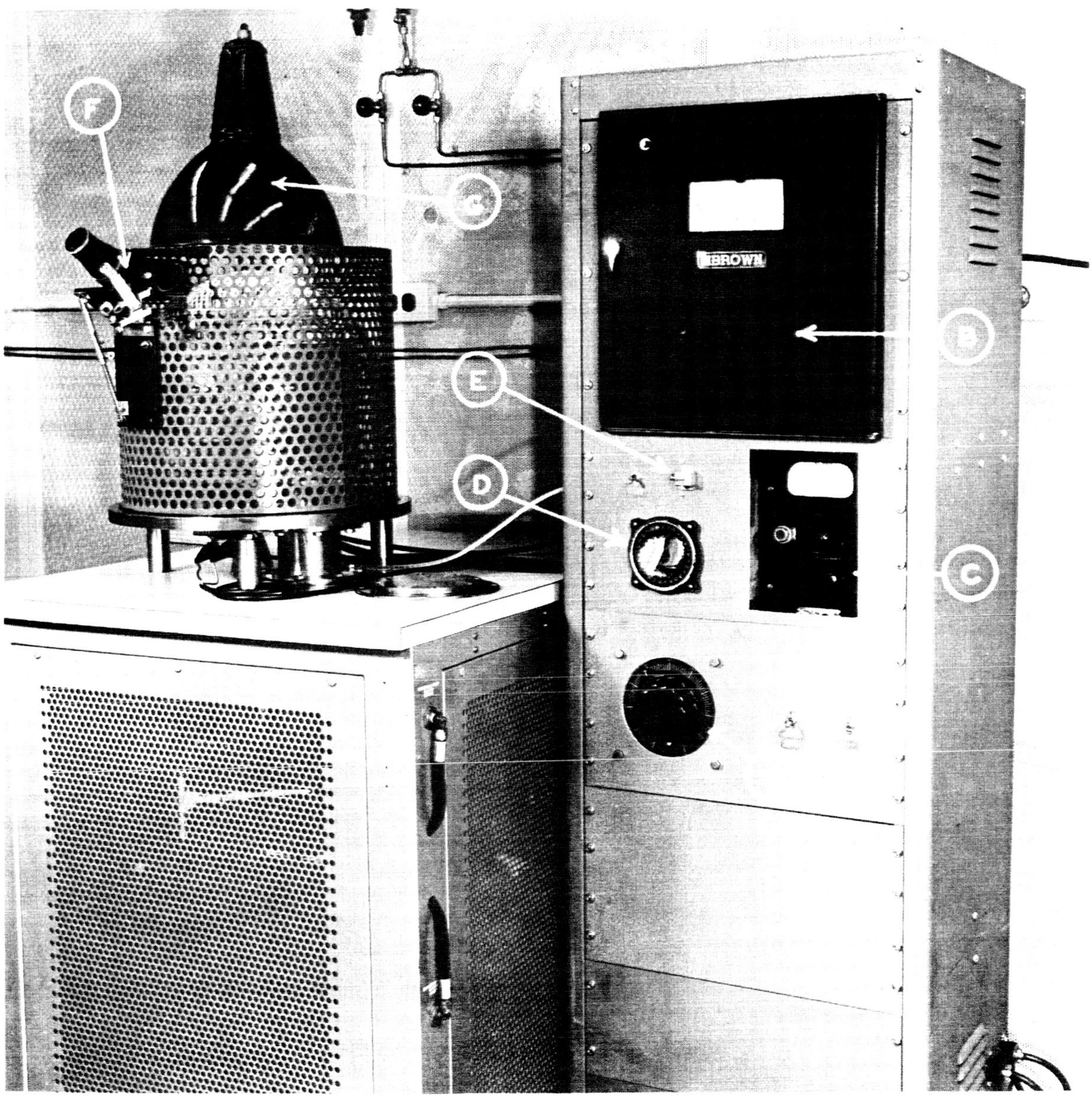
SPECIMEN INSTALLED IN ALUMINUM FIN THERMAL CYCLING RIG INSTRUMENTATION FLANGE

A- SPECIMEN
B- COPPER HEATING BLOCK
C- CARTRIDGE HEATER
D- THERMOCOUPLE FEEDTHROUGH
E- POWER FEEDTHROUGH



TYPICAL TEST SPECIMEN WITH THERMOCOUPLES FOR ALUMINUM FIN THERMAL CYCLING RIG

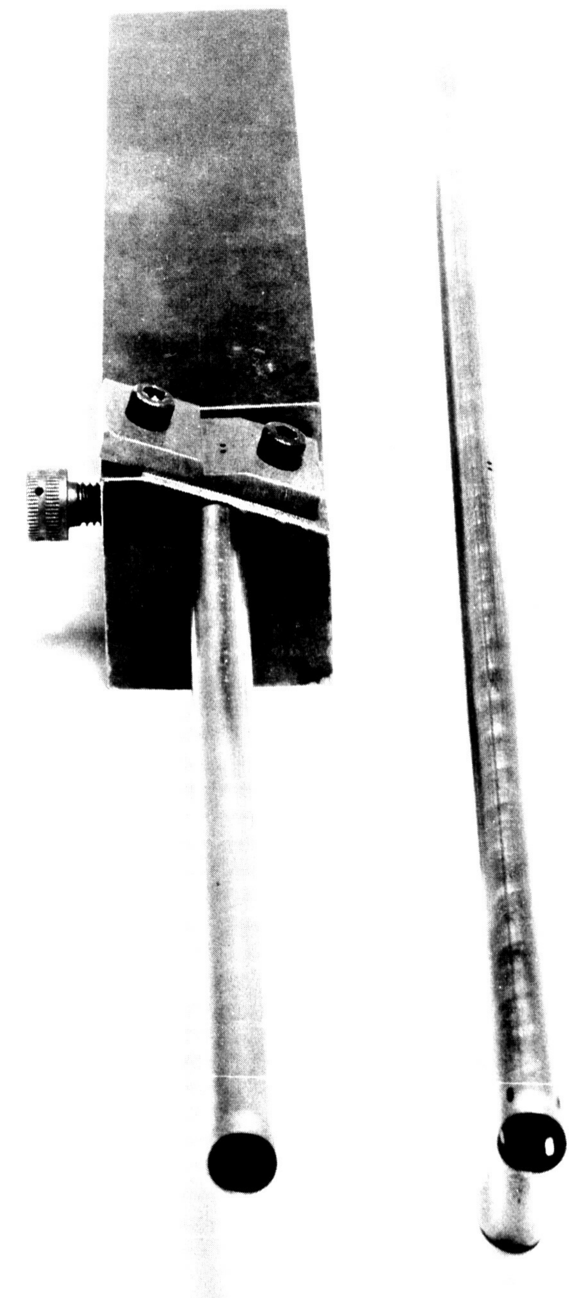
Figure 36



ALUMINUM FIN THERMAL CYCLING RIG

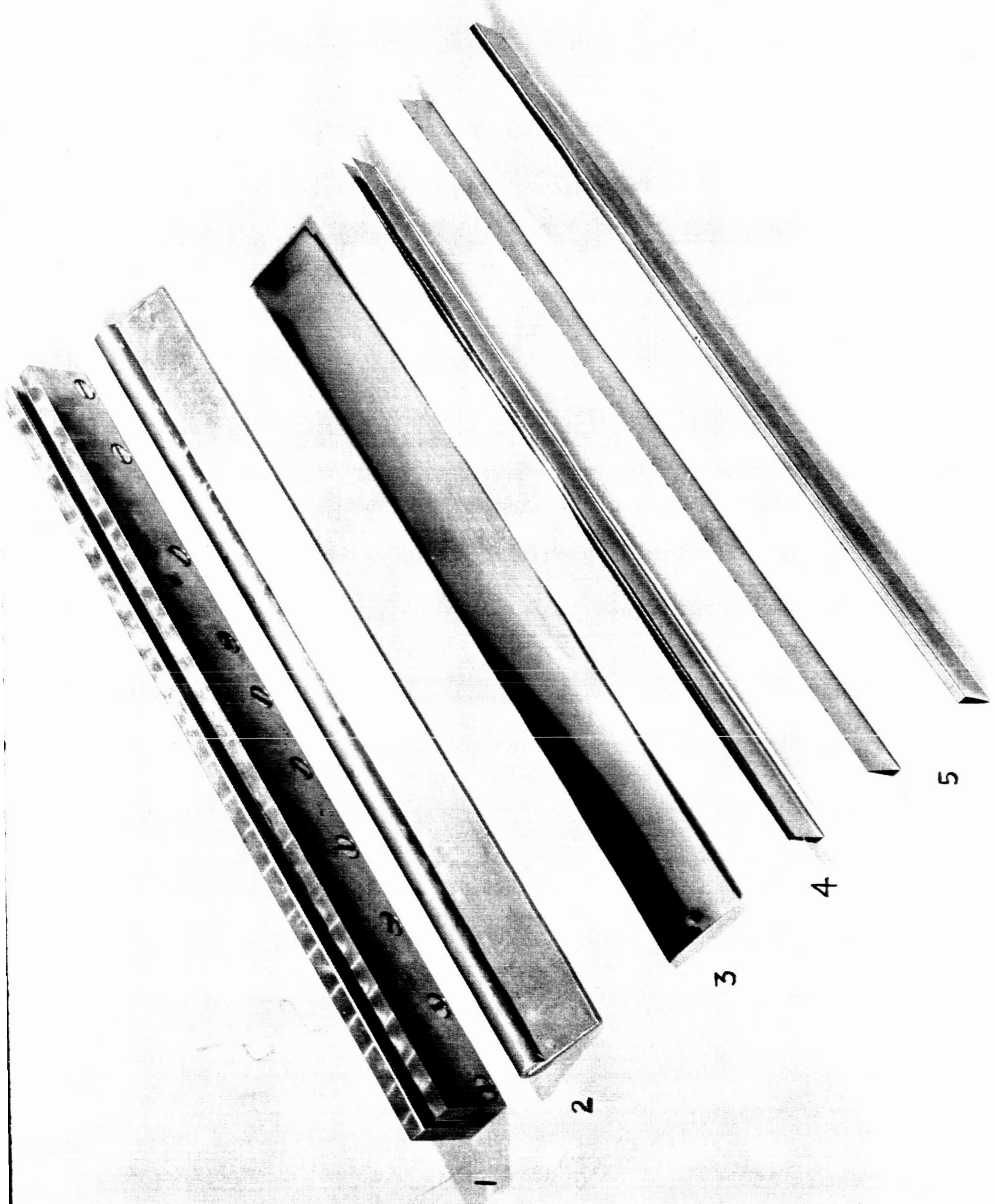
A. SPECIMEN HEATER POWER CONTROL
B. POTENTIOMETER
C. VOLTMETER
D. THERMOCOUPLE SELECTOR SWITCH
E. ELAPSED TIME INDICATOR
F. CAMERA MOUNT
G. OBSERVATION LAMP

Figure 37



JIG FOR DRILLING SPECIMEN BLACK-BODY HOLES

Figure 38

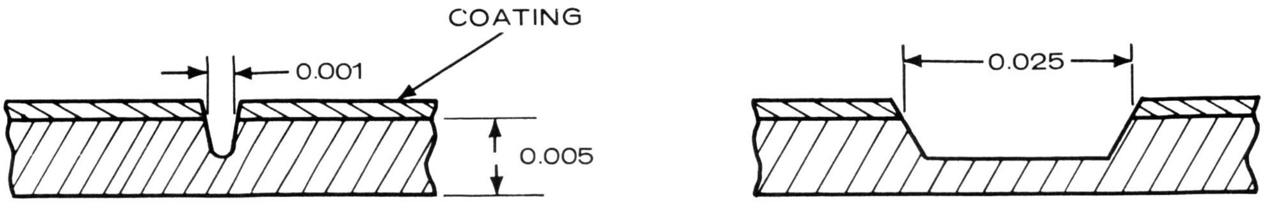


JIG FOR FORMING TRIANGULAR-SHAPED SPECIMENS
1- JIG
2- FORMING BLADE
3- UNPROCESSED STRIP
4- UNWELDED CHANNEL
5- COMPLETED SPECIMEN

XP-28862

Figure 39

SWAGING PROCESS FOR THERMOCOUPLE ATTACHMENT



COATING REMOVED AND TAPERED SLOT FORMED

THERMOCOUPLE WIRE FORCED TO BOTTOM OF SLOT

WIRE COVERED BY SWAGING

Figure 40

TYPICAL SPECTROPHOTOMETER BEAM POWER RATIO SCANS (PORTION OF WAVELENGTH RANGE)

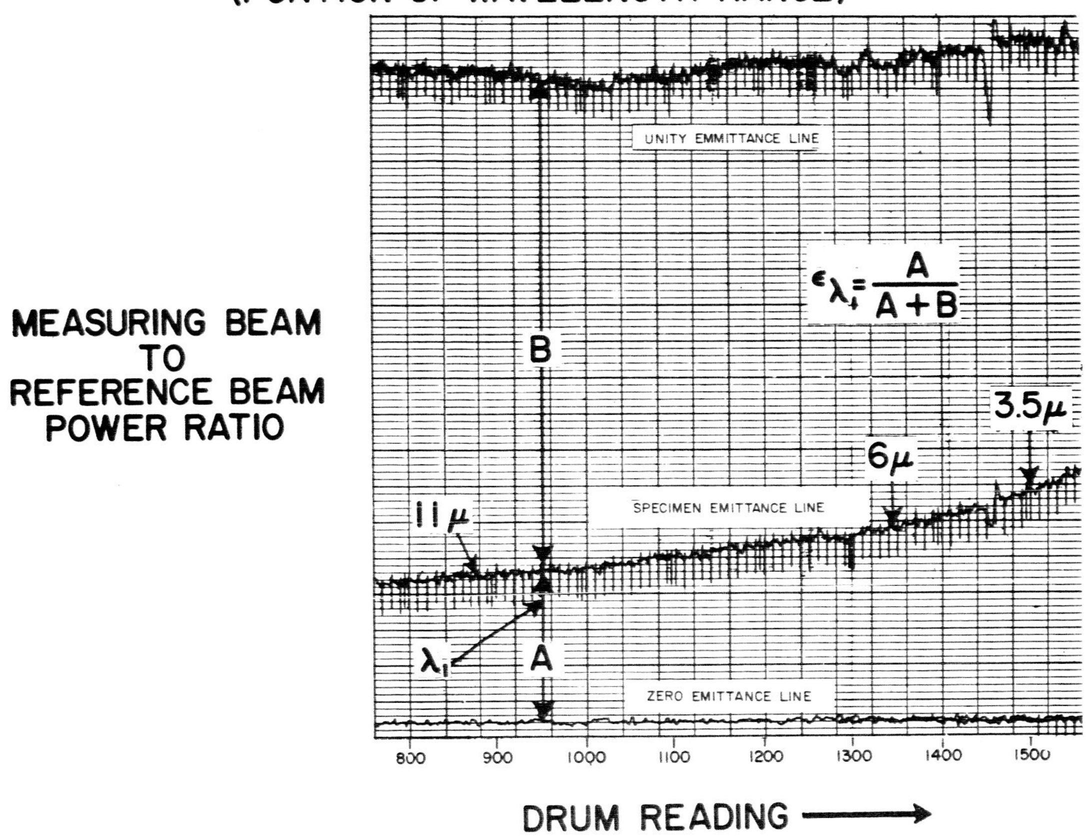


Figure 41

DRAWING OF CIRCULAR TUBULAR EMITTANCE SPECIMEN SHOWING THERMOCOUPLE AND POTENTIAL LEAD LOCATIONS WHEN PREPARED FOR MEASUREMENTS IN THE SPECTRAL EMITTANCE RIG

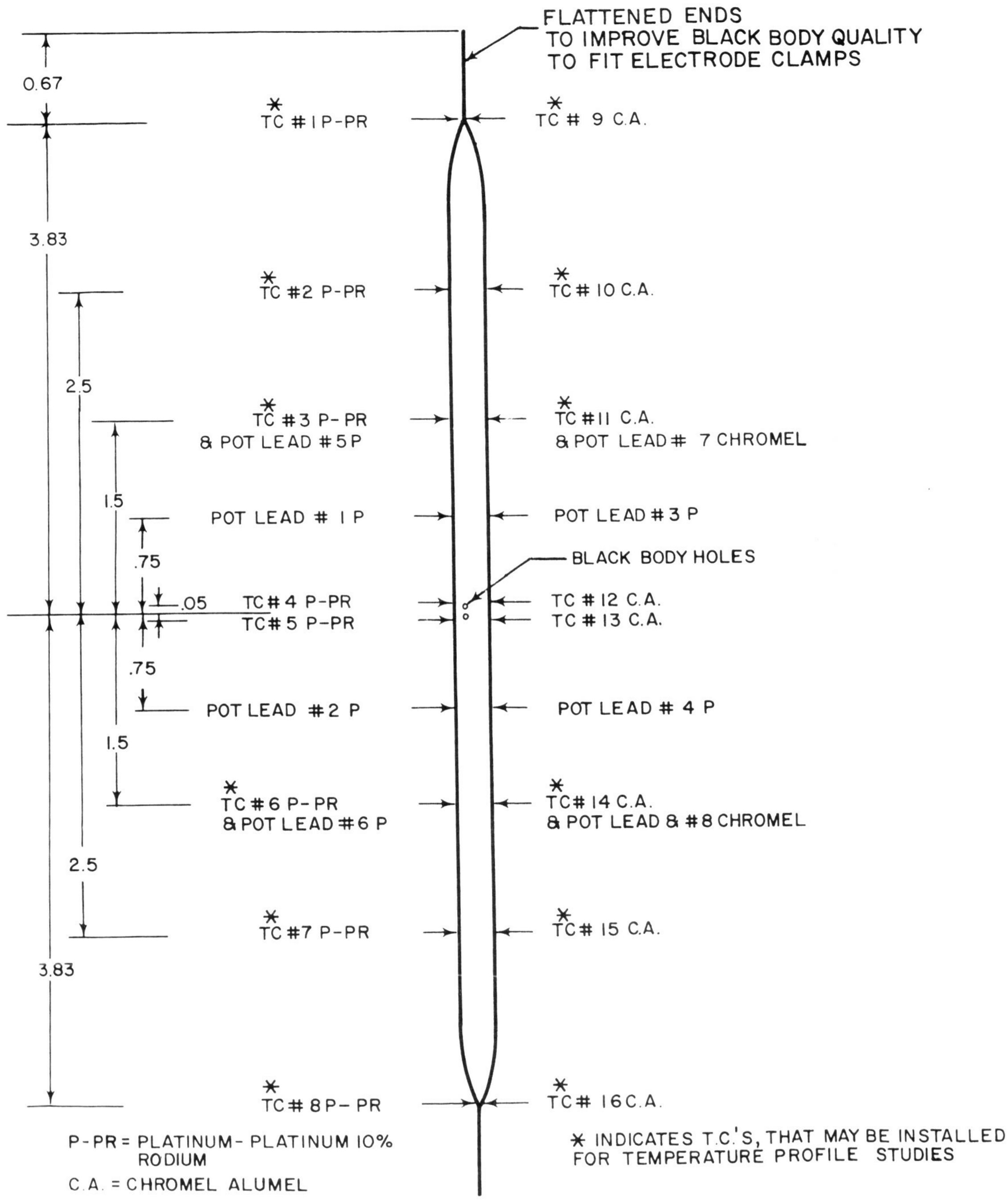


Figure 42

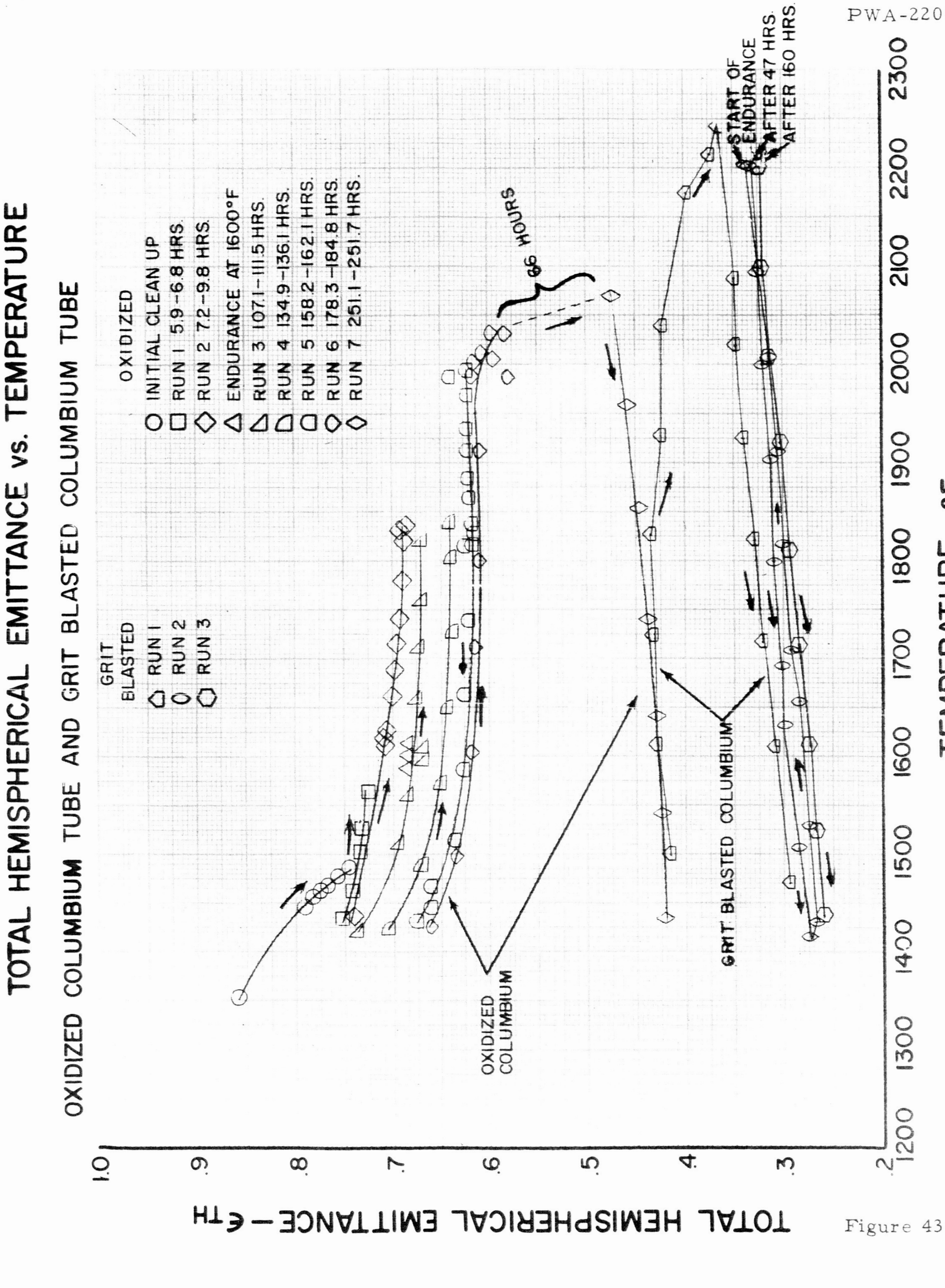

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
OXIDIZED COLUMBIUM TUBE AND GRIT BLASTED COLUMBIUM TUBE
GRIT BLASTED
RUN 1
RUN 2
RUN 3
OXIDIZED
INITIAL CLEAN UP
RUN 1 5.9-6.8 HRS.
RUN 2 7.2-9.8 HRS.
ENDURANCE AT 1600°F
RUN 3 107.1-111.5 HRS.
RUN 4 134.9-136.1 HRS.
RUN 5 158.2-162.1 HRS.
RUN 6 178.3-184.8 HRS.
RUN 7 251.1-251.7 HRS.
66 HOURS
OXIDIZED COLUMBIUM
GRIT BLASTED COLUMBIUM
START OF ENDURANCE
AFTER 47 HRS.
AFTER 160 HRS.
TOTAL HEMISPHERICAL EMITTANCE — ϵ_{TH}
TEMPERATURE — °F
1.0
.9
.8
.7
.6
.5
.4
.3
.2
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300

Figure 43

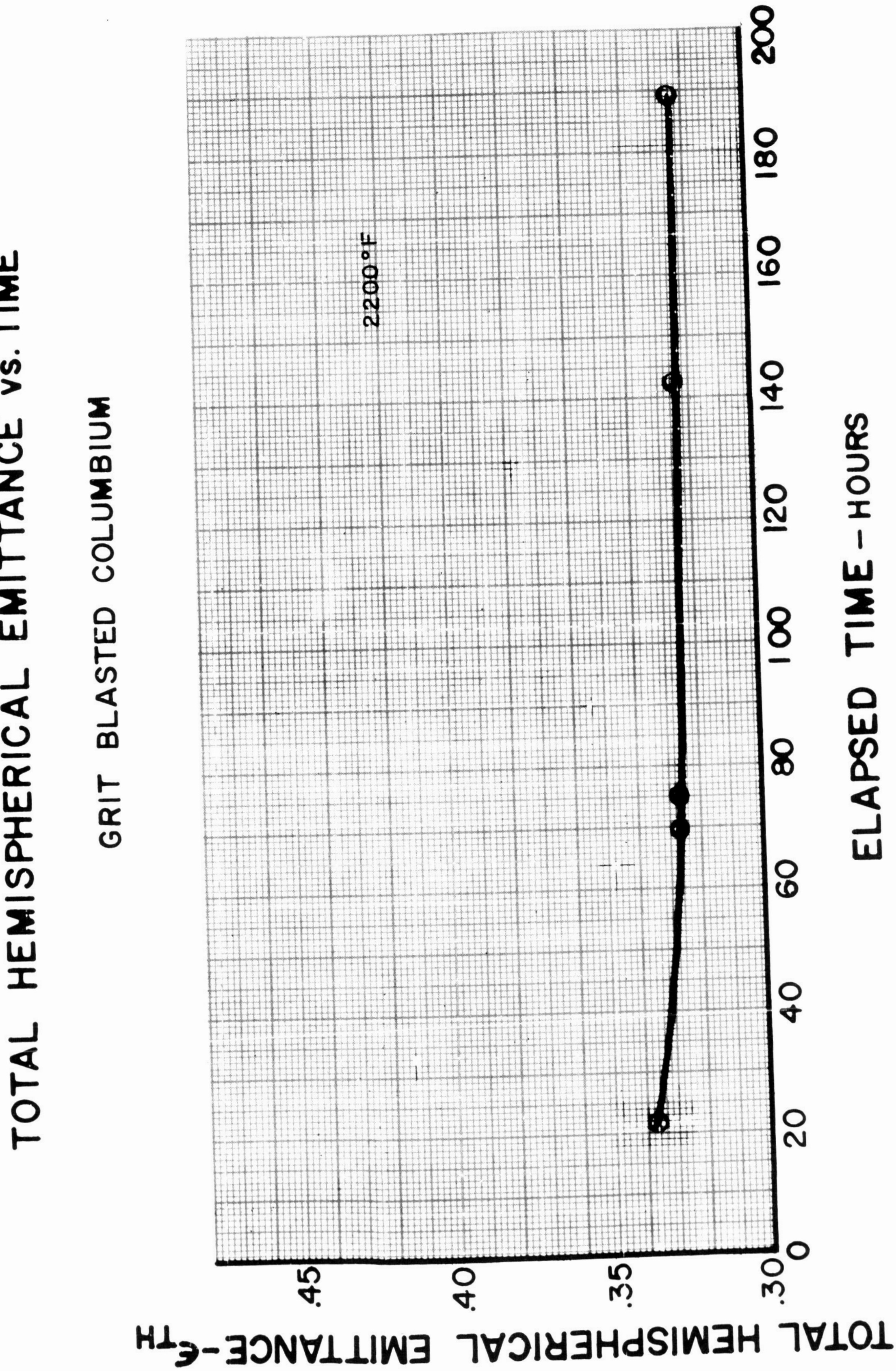
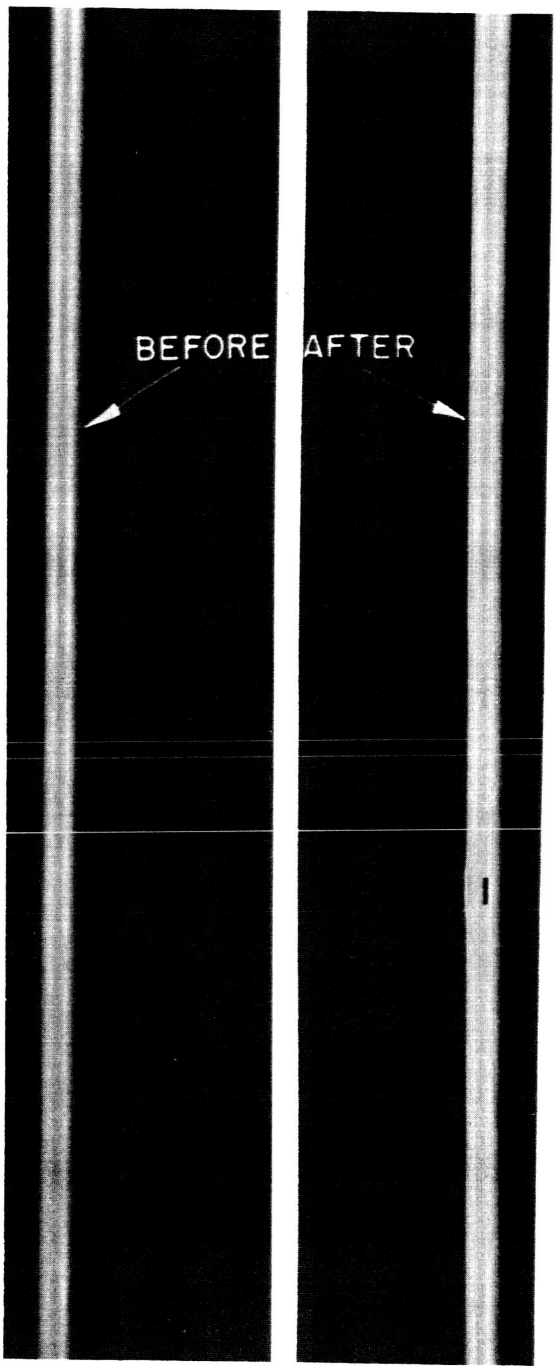

TOTAL HEMISPHERICAL EMITTANCE vs. TIME
GRIT BLASTED COLUMBIUM
2200°F
ELAPSED TIME - HOURS
0
20
40
60
80
100
120
140
160
180
200
TOTAL HEMISPHERICAL EMITTANCE - ϵ_{TH}
.30
.35
.40
.45

Figure 44



APPEARANCE OF GRIT BLASTED COLUMBIUM TUBE BEFORE AND AFTER TESTING

SPECTRAL NORMAL EMITTANCE vs. TEMPERATURE

OXIDIZED COLUMBIUM TUBE

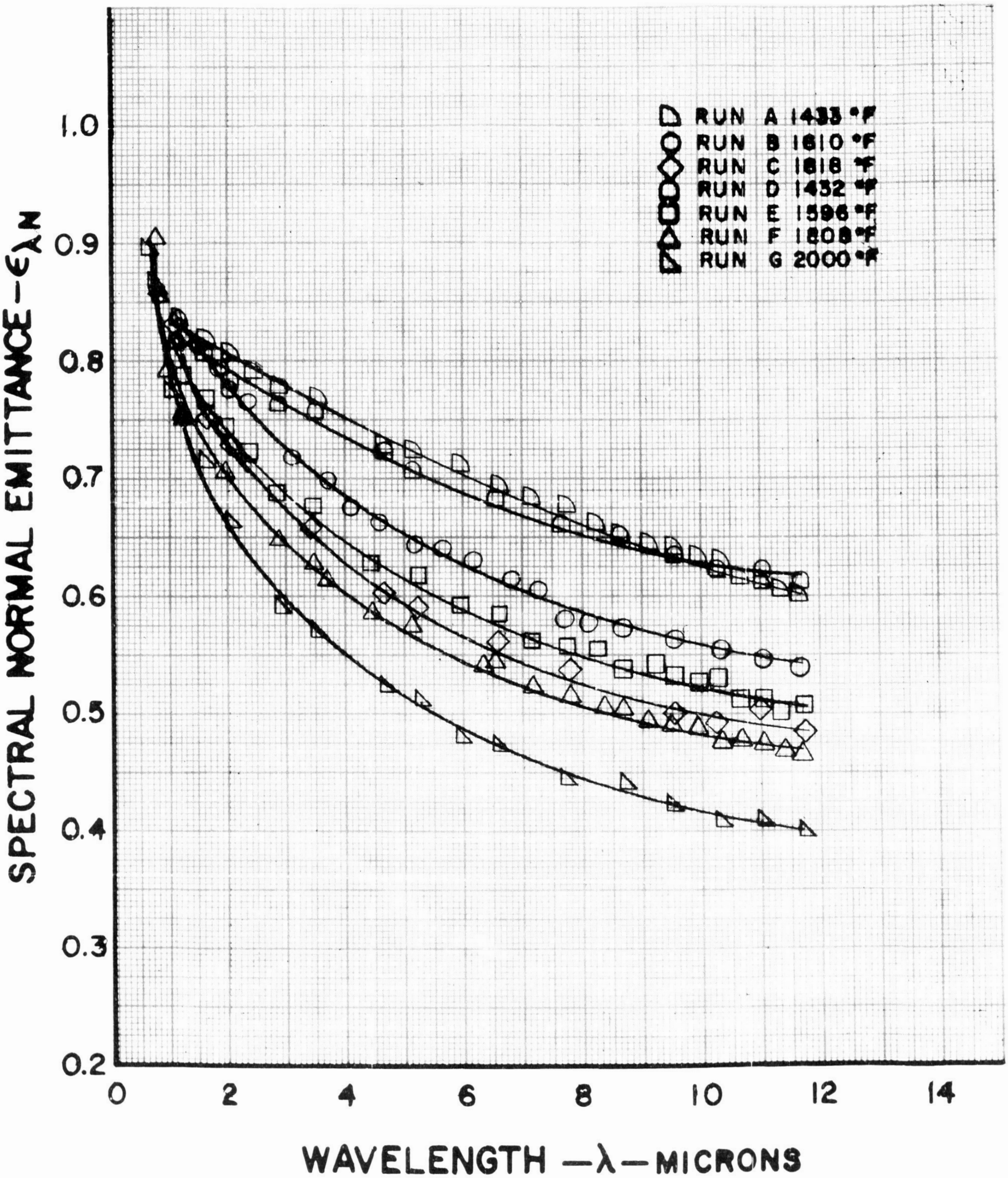
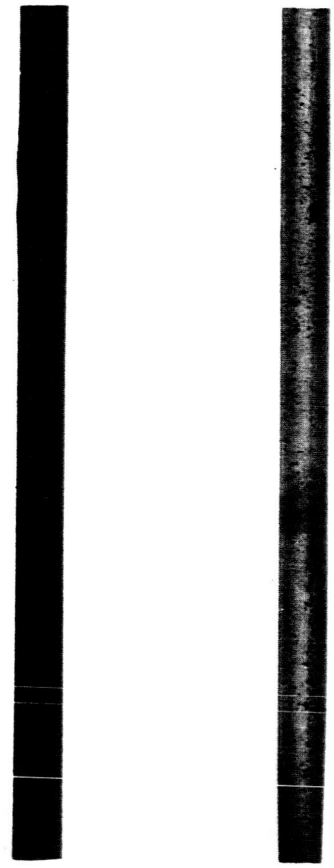


Figure 46



BEFORE AFTER

APPEARANCE OF OXIDIZED COLUMBIUM TUBE BEFORE AND AFTER TESTING

Figure 47

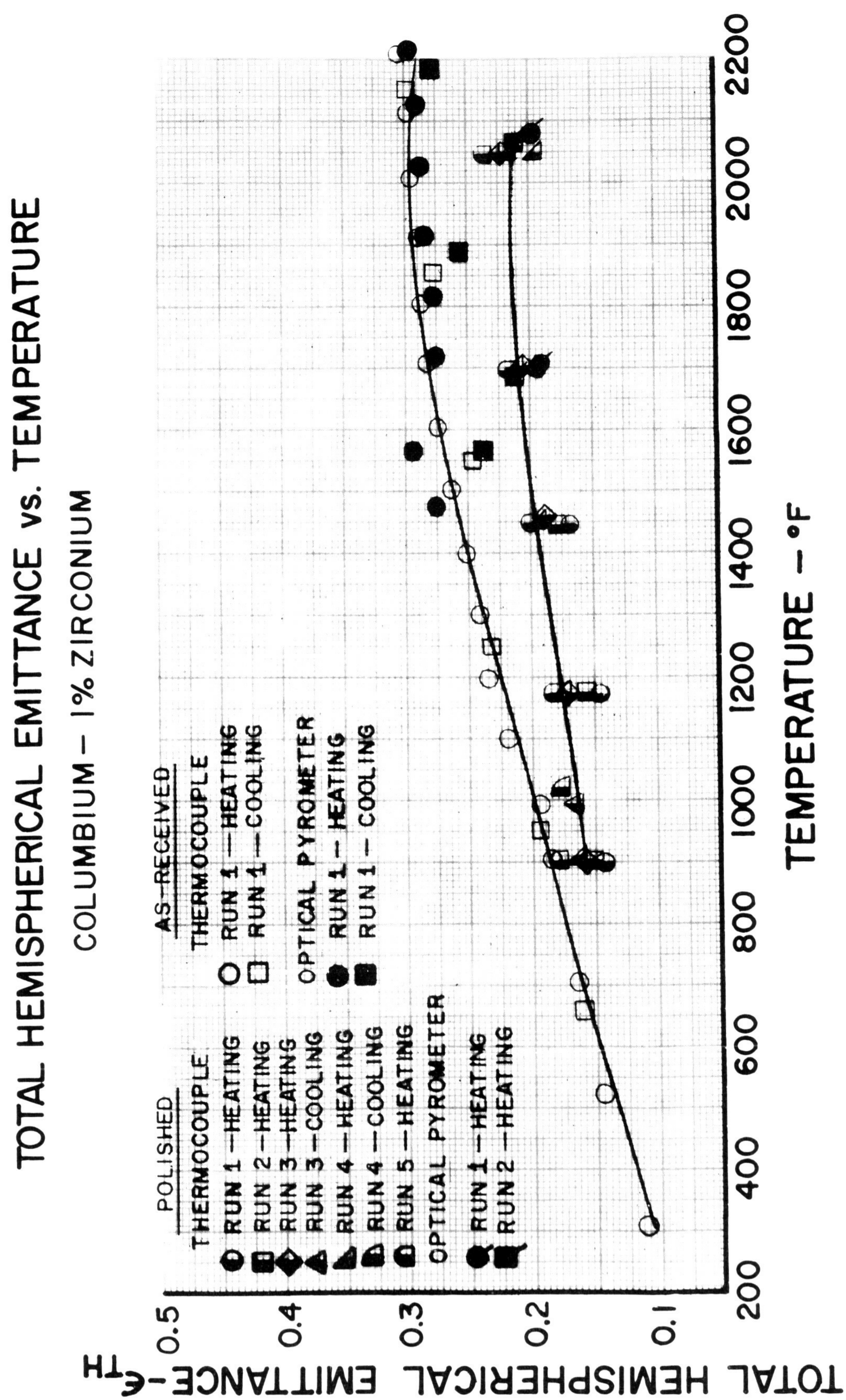

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COLUMBIUM – 1% ZIRCONIUM
POLISHED
THERMOCOUPLE
RUN 1 — HEATING
RUN 2 — HEATING
RUN 3 — HEATING
RUN 3 — COOLING
RUN 4 — HEATING
RUN 4 — COOLING
RUN 5 — HEATING
OPTICAL PYROMETER
RUN 1 — HEATING
RUN 2 — HEATING
AS-RECEIVED
THERMOCOUPLE
RUN 1 — HEATING
RUN 1 — COOLING
OPTICAL PYROMETER
RUN 1 — HEATING
RUN 1 — COOLING
TOTAL HEMISPHERICAL EMITTANCE – ϵ_{TH}
0.5
0.4
0.3
0.2
0.1
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 48

SPECTRAL NORMAL EMITTANCE vs. WAVE LENGTH
UNCOATED, POLISHED COLUMBIUM – 1% ZIRCONIUM

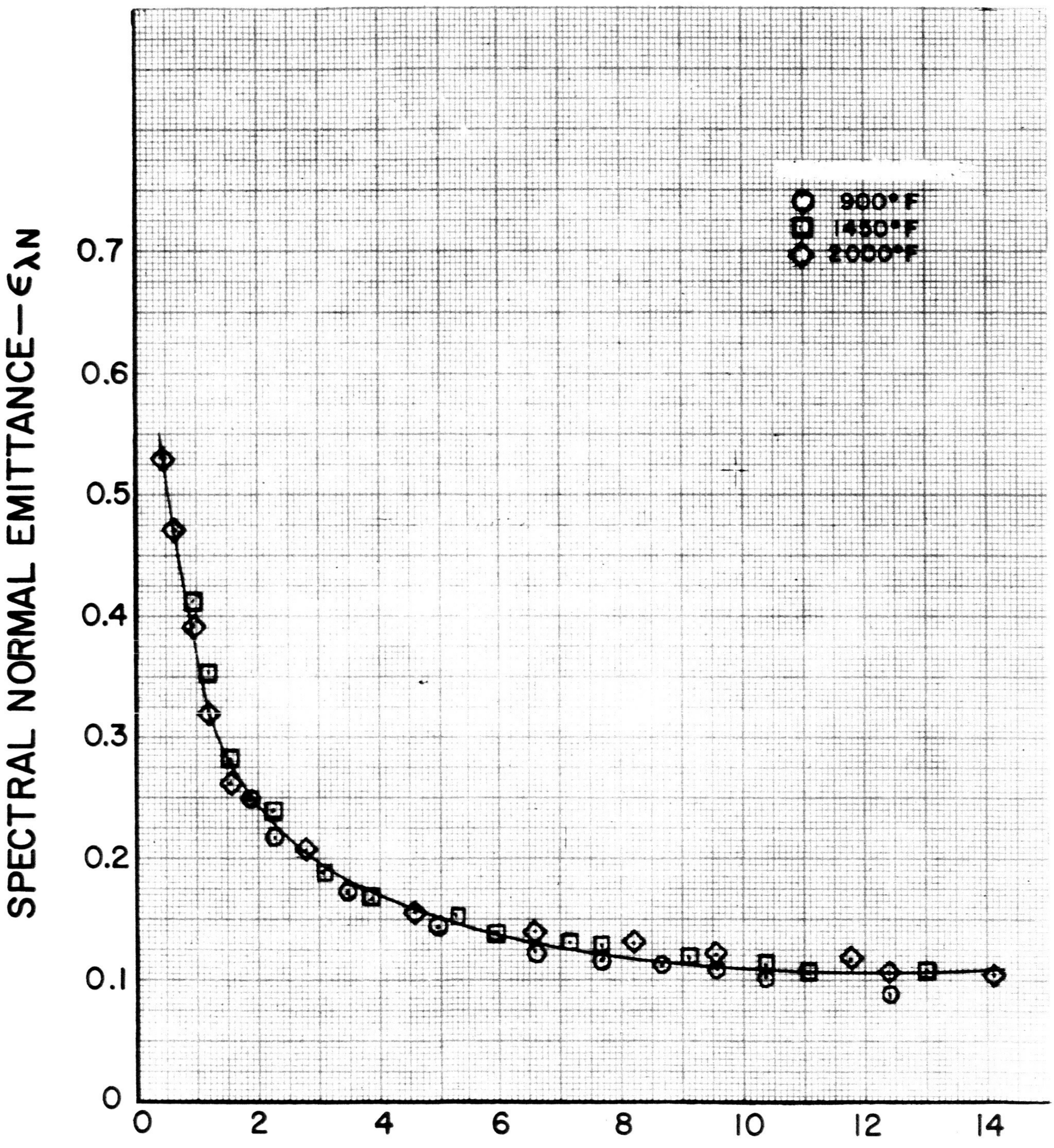


Figure 49

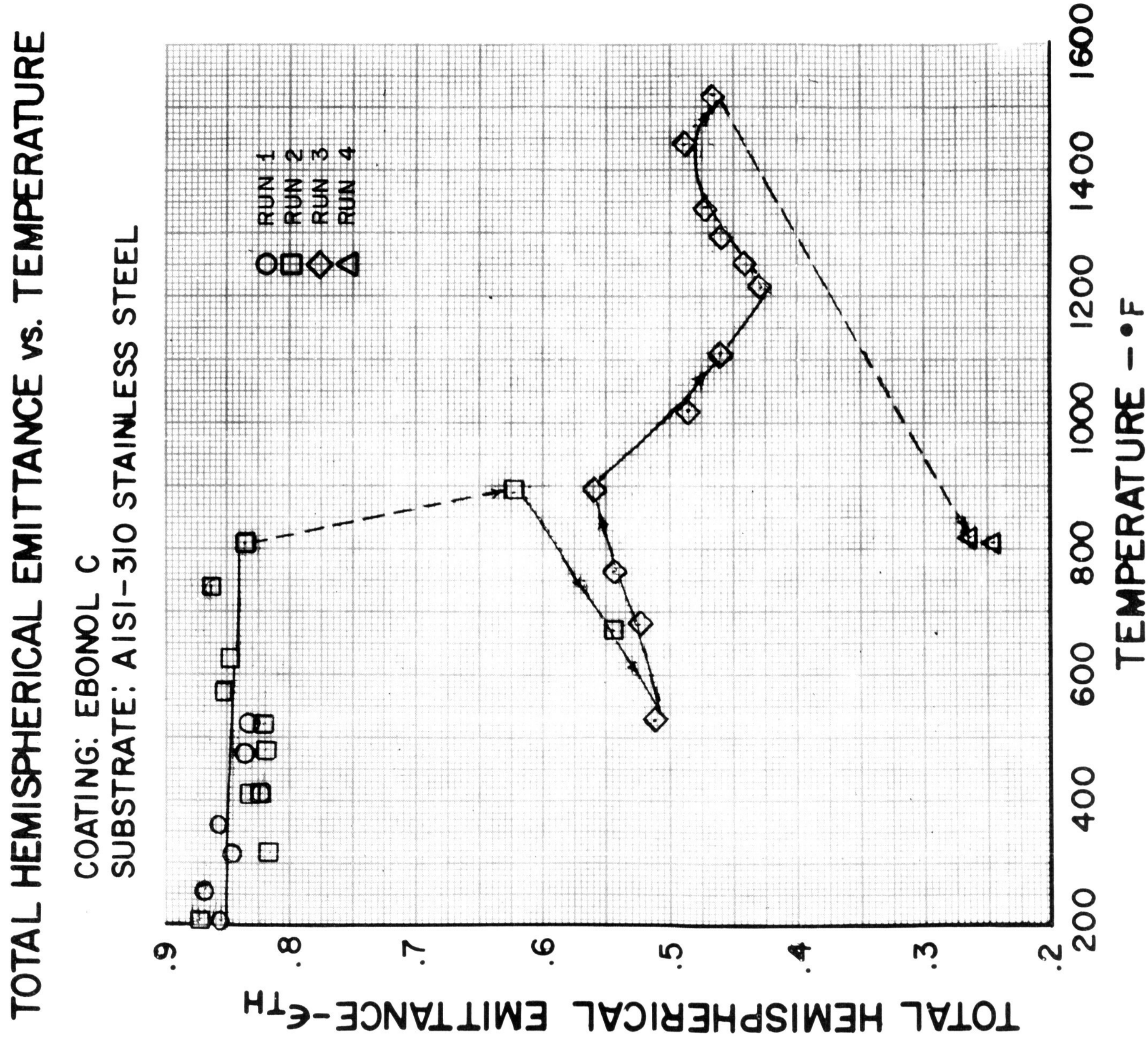
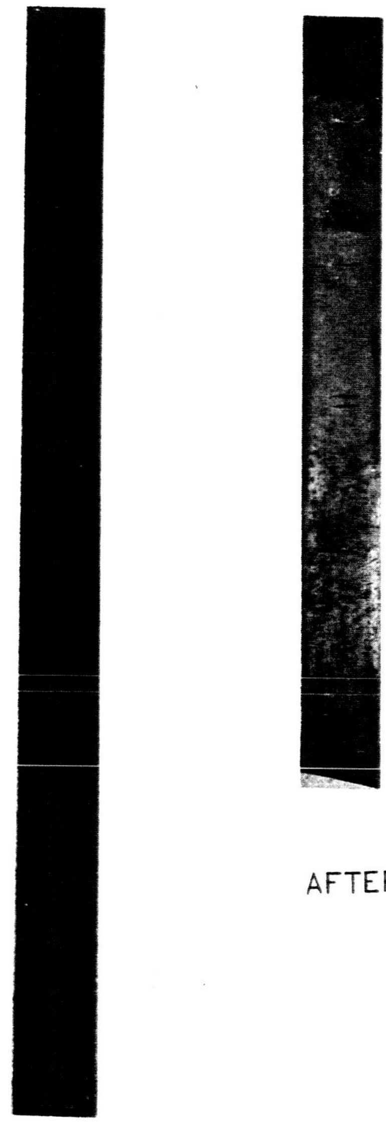

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: EBONOL C
SUBSTRATE: AISI-310 STAINLESS STEEL
RUN 1
RUN 2
RUN 3
RUN 4
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
TEMPERATURE — °F
.9
.8
.7
.6
.5
.4
.3
.2
200
400
600
800
1000
1200
1400
1600

Figure 50



AFTER

BEFORE

APPEARANCE OF AISI-310 STAINLESS STEEL STRIP COATED WITH CUPRIC OXIDE BEFORE AND AFTER TESTING

SPECTRAL NORMAL EMITTANCE vs. WAVELENGTH

MOLYBDENUM

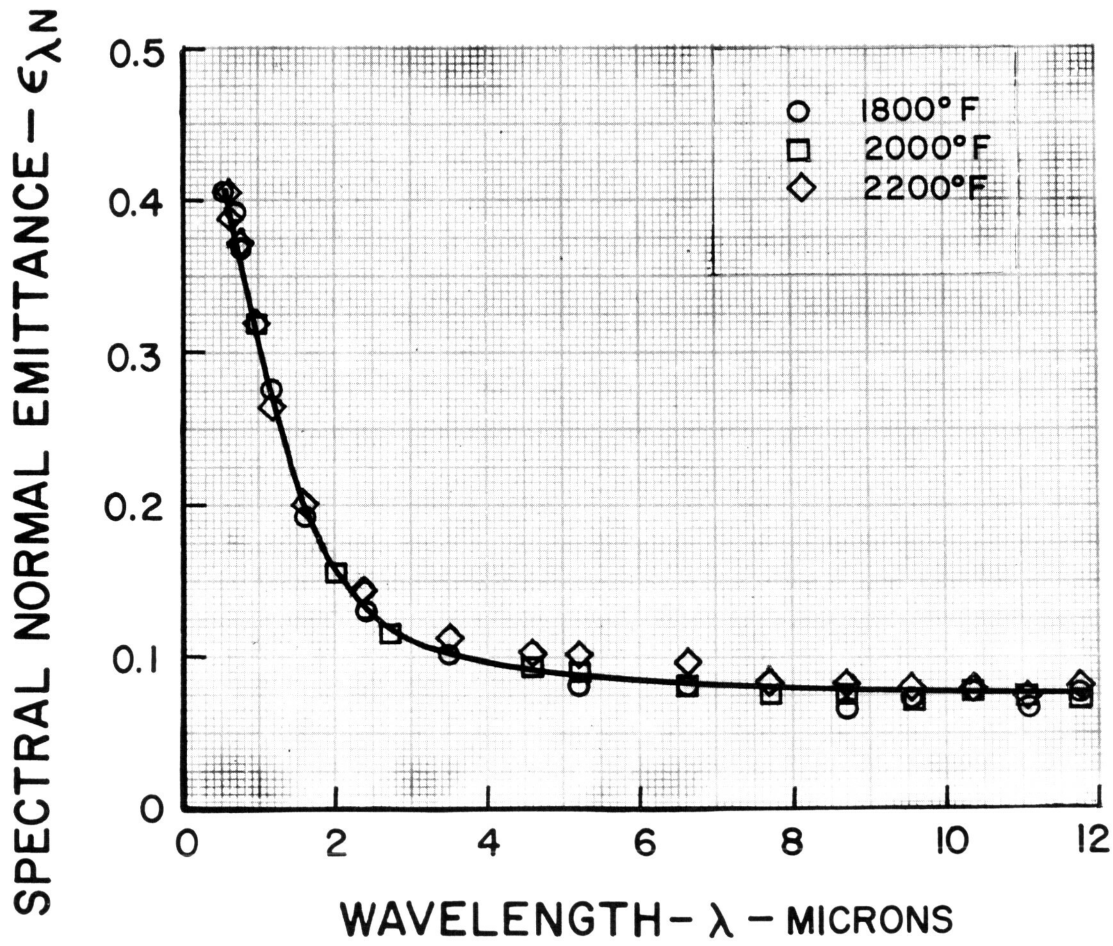


Figure 52

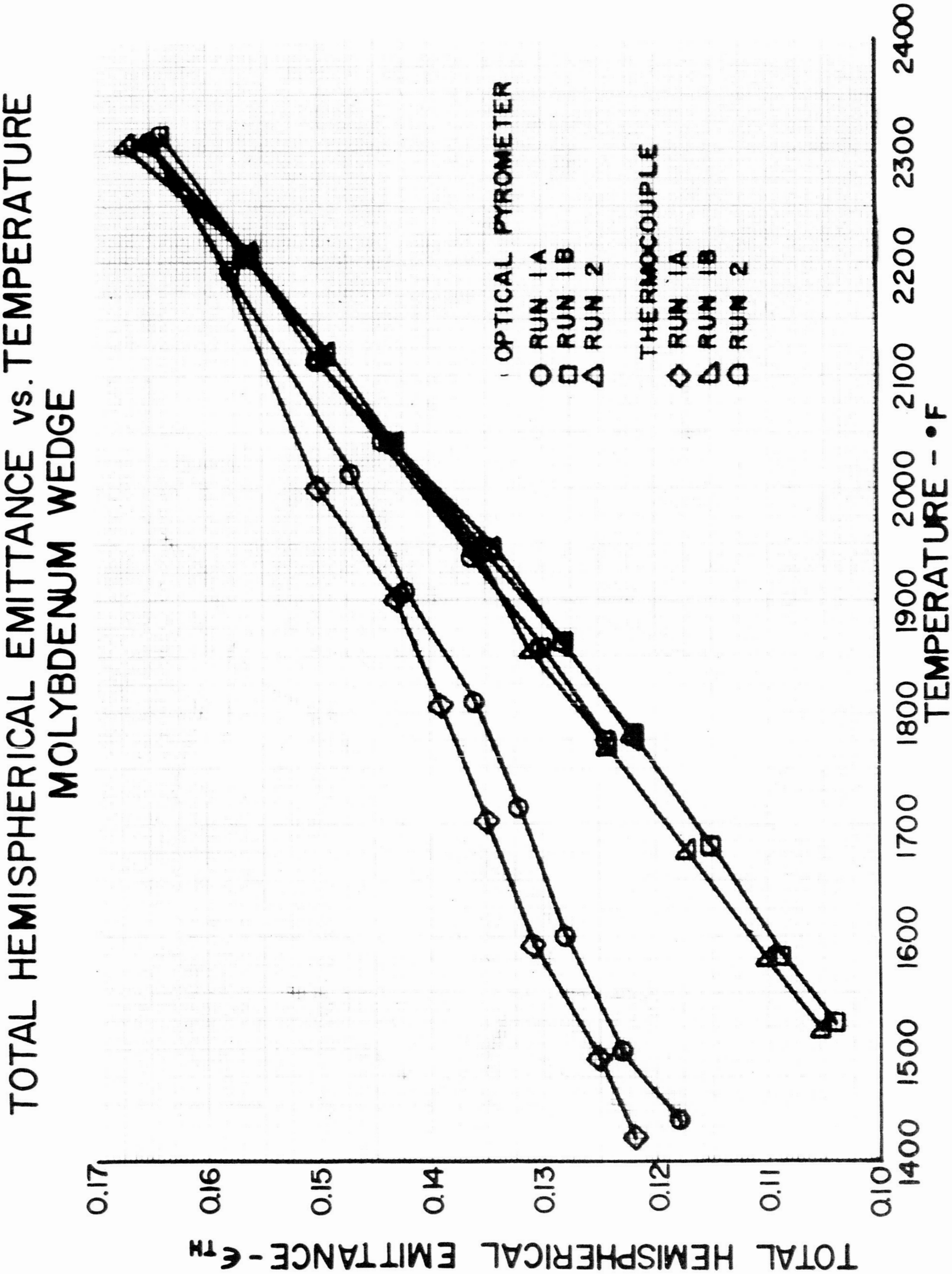

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
MOLYBDENUM WEDGE
OPTICAL PYROMETER
RUN 1A
RUN 1B
RUN 2
THERMOCOUPLE
RUN 1A
RUN 1B
RUN 2
TOTAL HEMISPHERICAL EMITTANCE - ϵ_{TH}
TEMPERATURE - °F
0.10
0.11
0.12
0.13
0.14
0.15
0.16
0.17
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

Figure 53

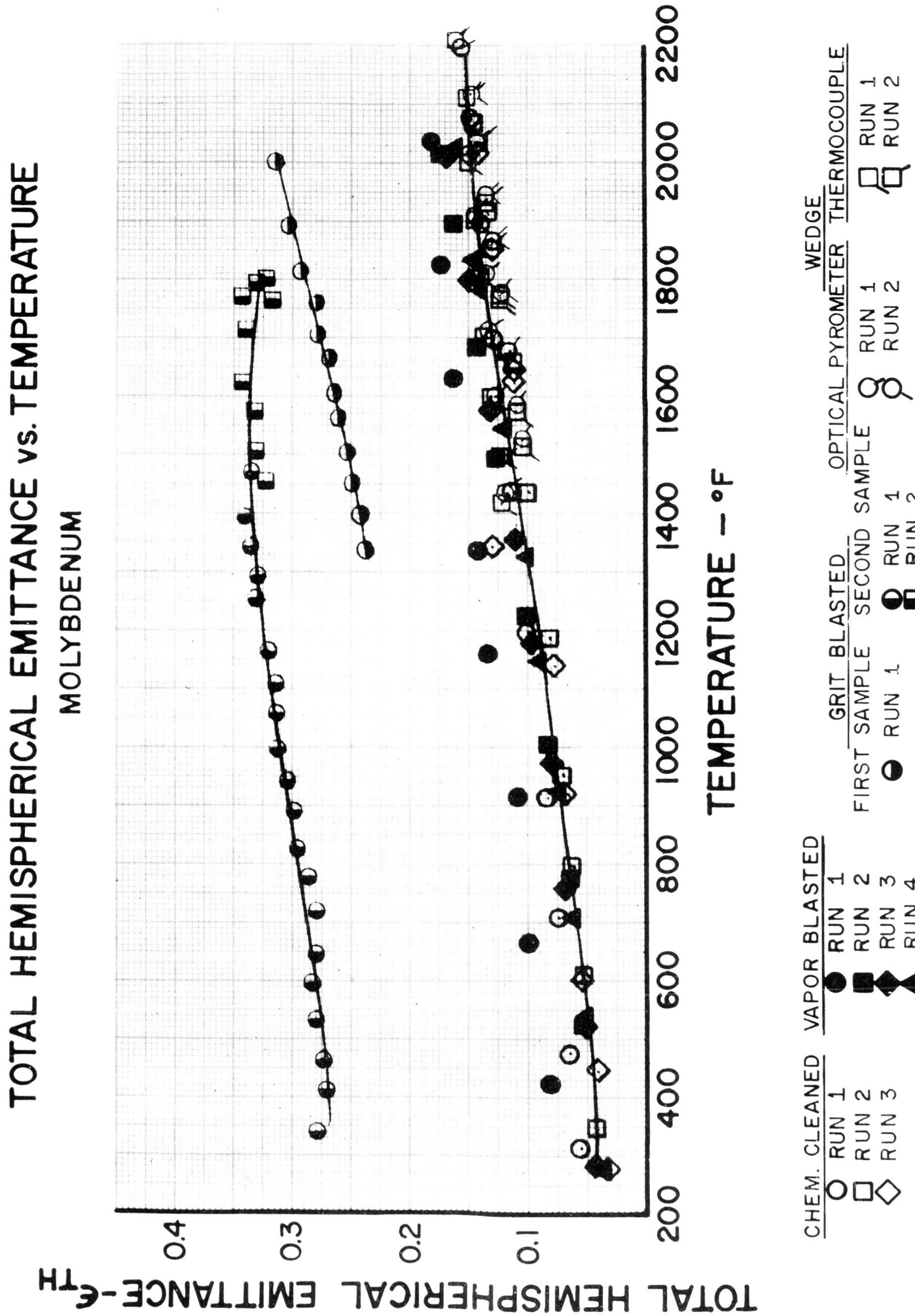

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
MOLYBDENUM
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
0.4
0.3
0.2
0.1
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F
CHEM. CLEANED
RUN 1
RUN 2
RUN 3
VAPOR BLASTED
RUN 1
RUN 2
RUN 3
RUN 4
GRIT BLASTED
FIRST SAMPLE
RUN 1
SECOND SAMPLE
RUN 1
RUN 2
OPTICAL PYROMETER
RUN 1
RUN 2
WEDGE THERMOCOUPLE
RUN 1
RUN 2

Figure 54

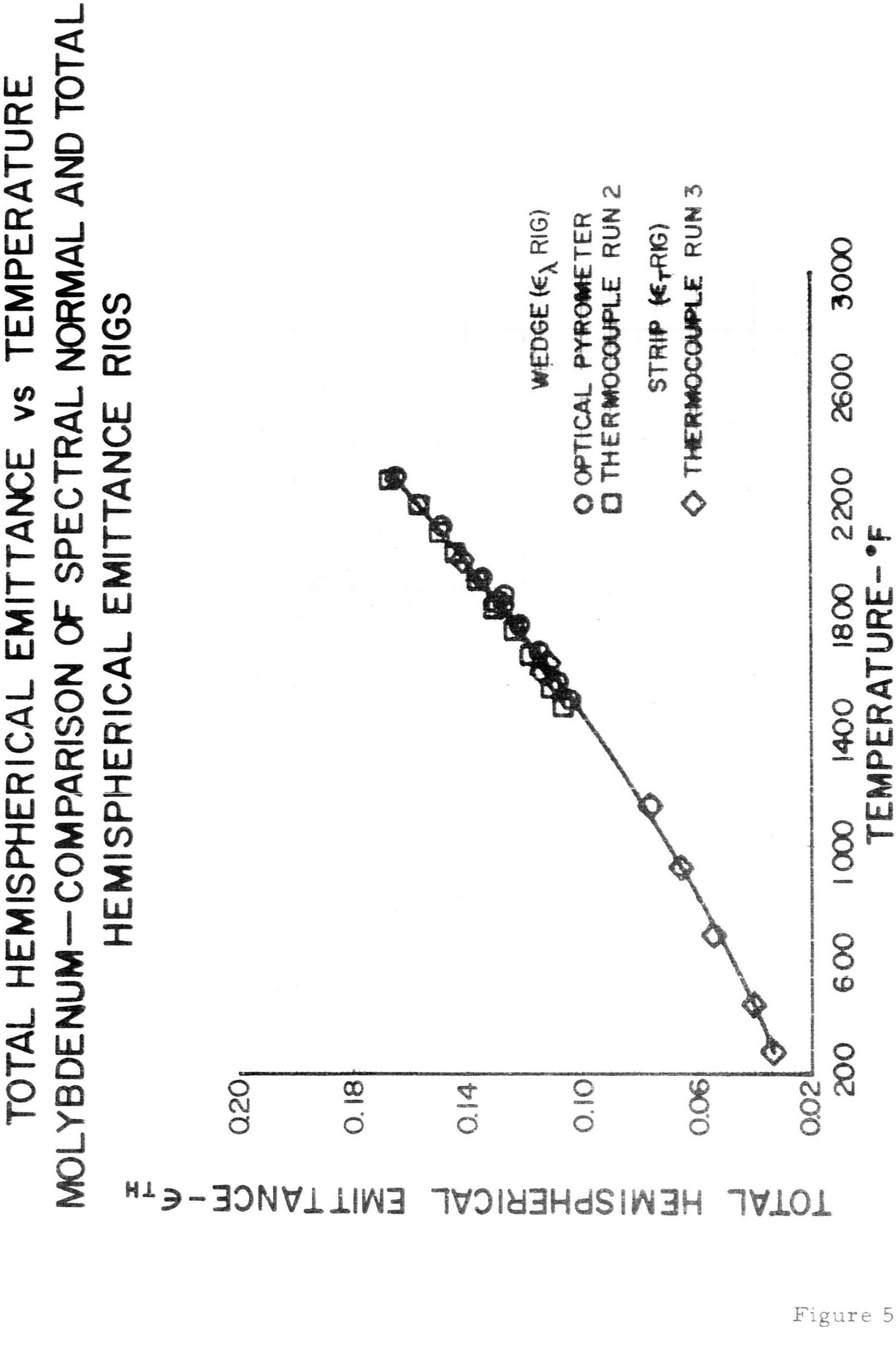

TOTAL HEMISPHERICAL EMITTANCE vs TEMPERATURE
MOLYBDENUM—COMPARISON OF SPECTRAL NORMAL AND TOTAL HEMISPHERICAL EMITTANCE RIGS
WEDGE (ϵ_λ RIG)
OPTICAL PYROMETER
THERMOCOUPLE RUN 2
STRIP (ϵ_T RIG)
THERMOCOUPLE RUN 3
TOTAL HEMISPHERICAL EMITTANCE - ϵ_{TH}
0.20
0.18
0.14
0.10
0.06
0.02
200
600
1000
1400
1800
2200
2600
3000
TEMPERATURE - °F

Figure 55

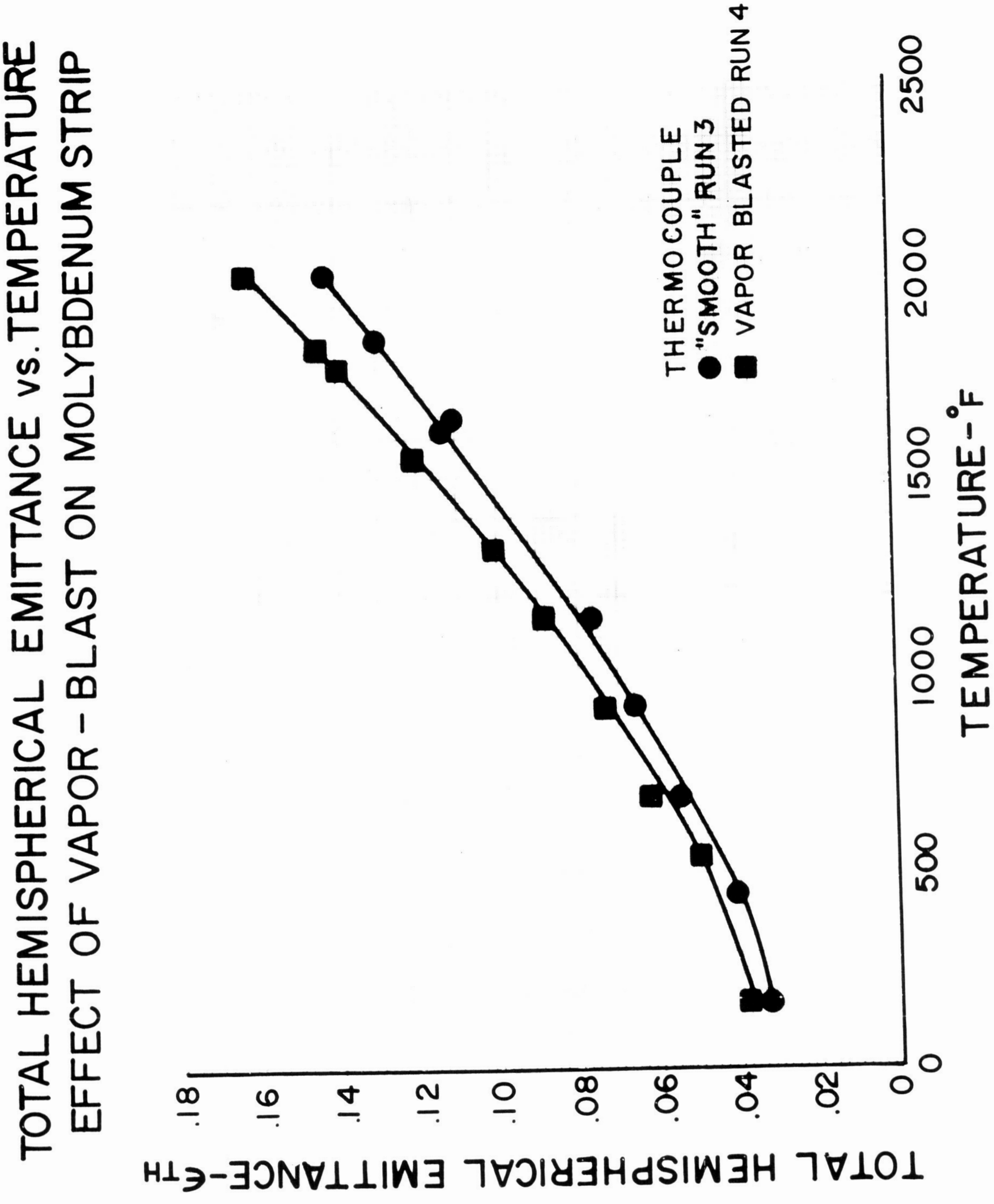

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
EFFECT OF VAPOR - BLAST ON MOLYBDENUM STRIP
TOTAL HEMISPHERICAL EMITTANCE-ϵTH
.18
.16
.14
.12
.10
.08
.06
.04
.02
0
0
500
1000
1500
2000
2500
TEMPERATURE-°F
THERMOCOUPLE
"SMOOTH" RUN 3
VAPOR BLASTED RUN 4

Figure 56

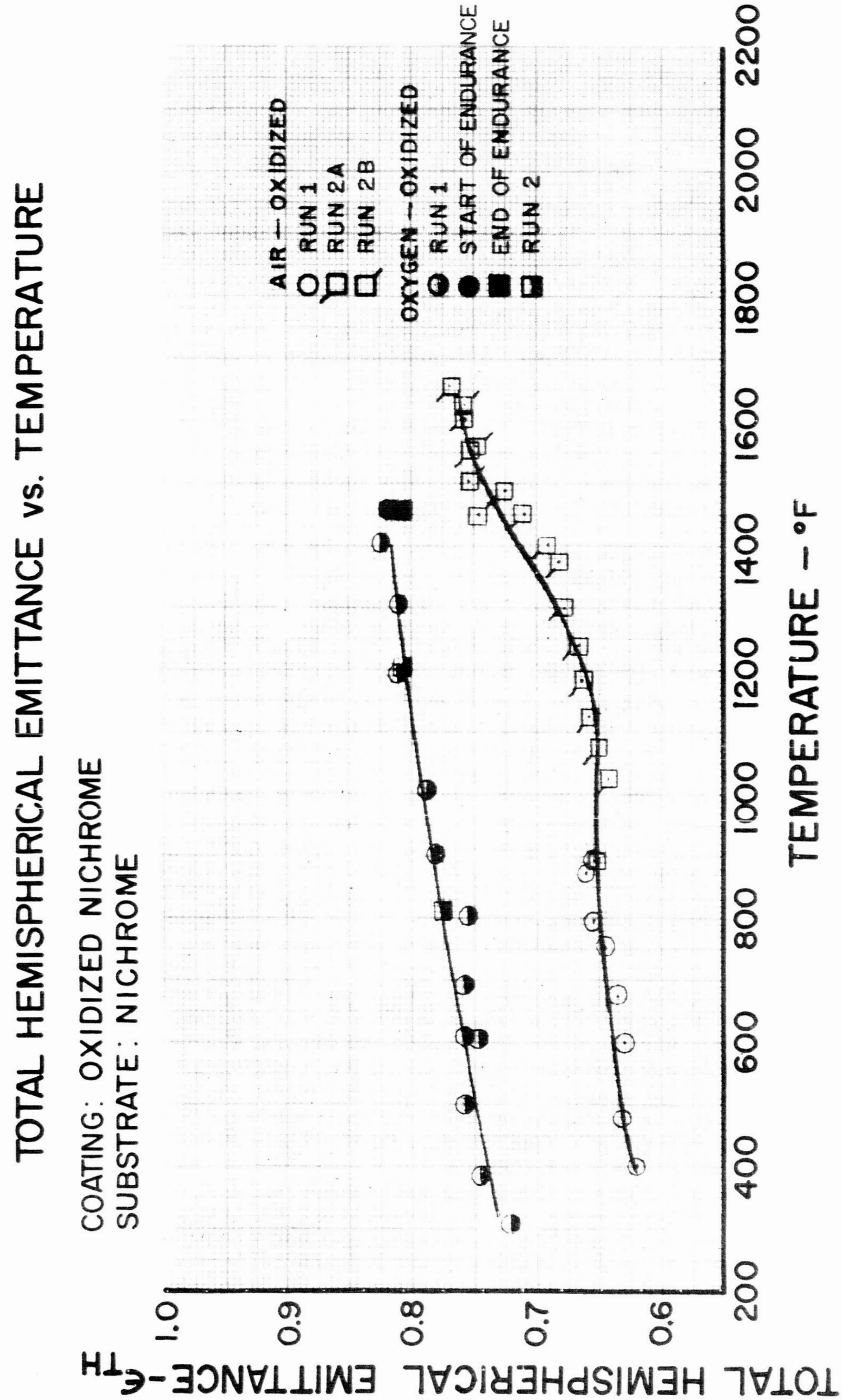

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: OXIDIZED NICHROME
SUBSTRATE: NICHROME
AIR — OXIDIZED
RUN 1
RUN 2A
RUN 2B
OXYGEN — OXIDIZED
RUN 1
START OF ENDURANCE
END OF ENDURANCE
RUN 2
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 57

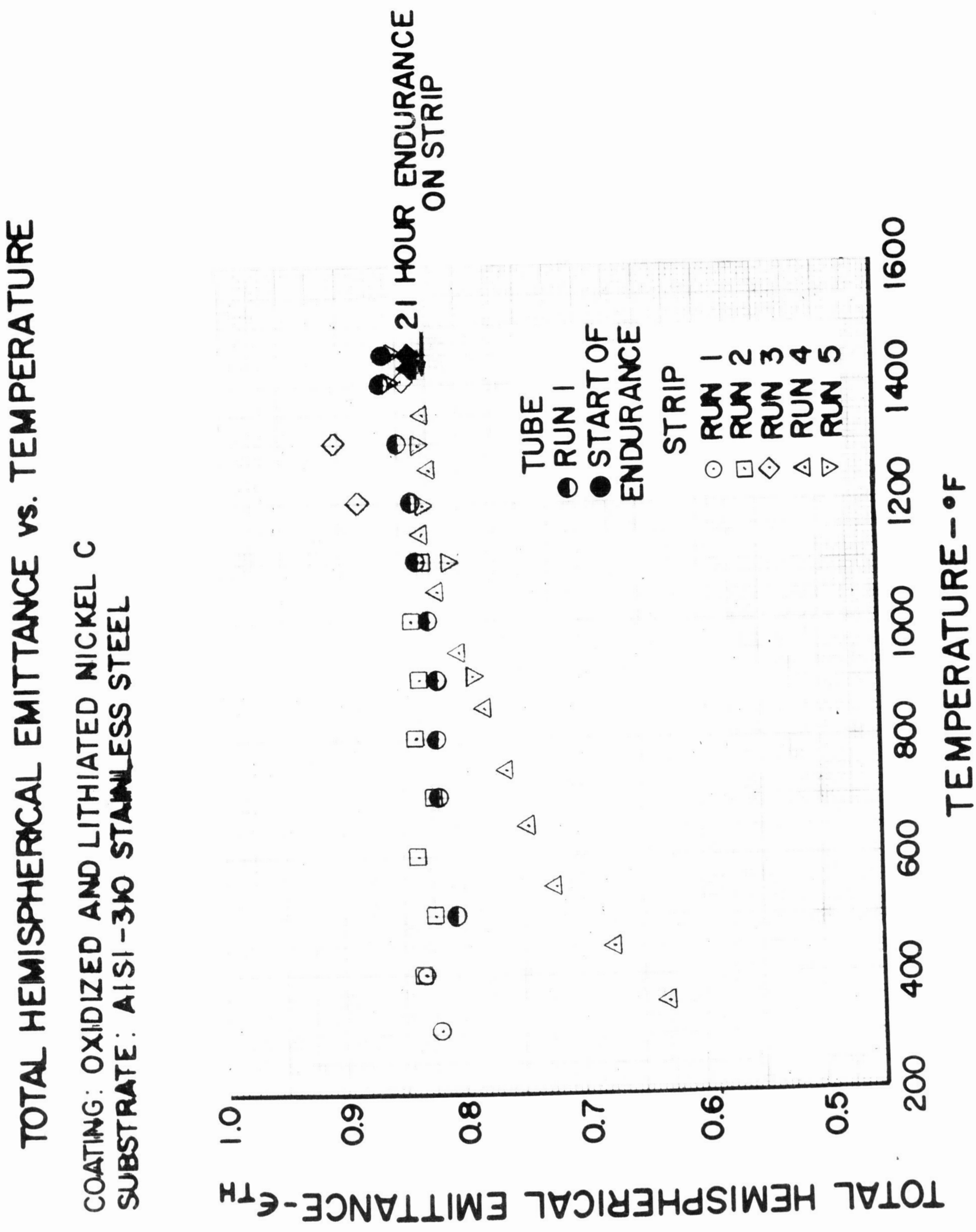
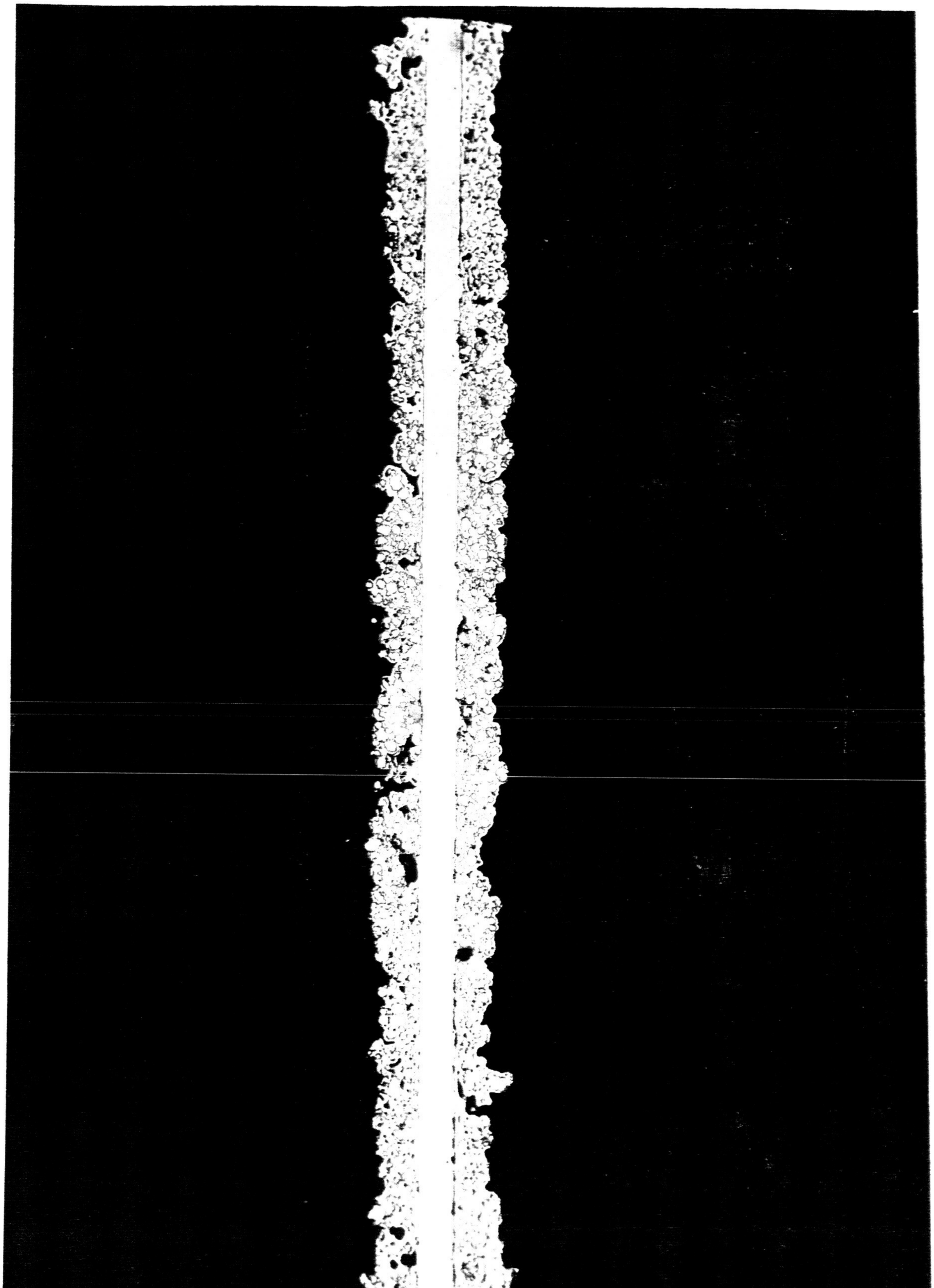
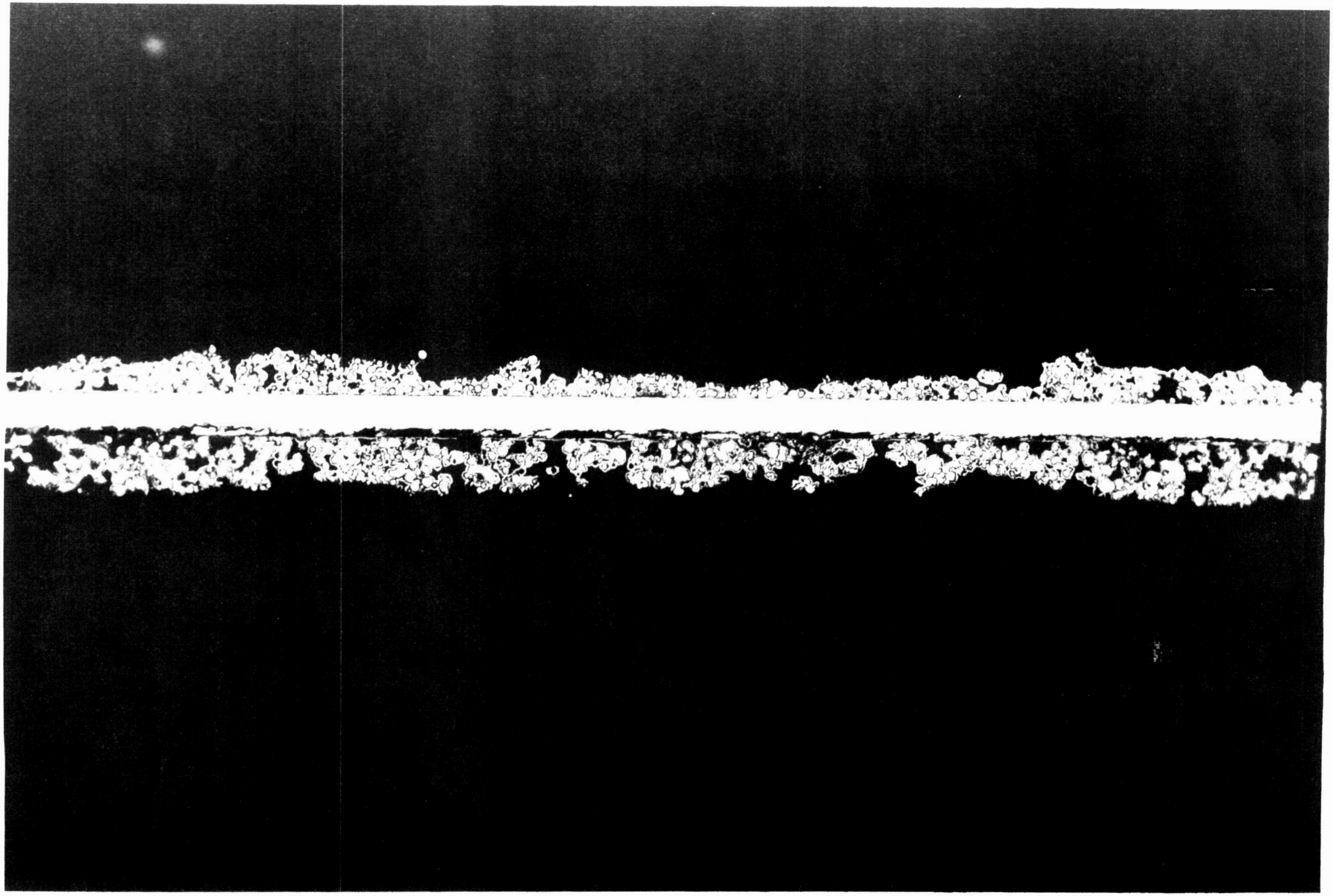

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: OXIDIZED AND LITHIATED NICKEL C
SUBSTRATE: AISI-310 STAINLESS STEEL
21 HOUR ENDURANCE ON STRIP
TUBE
RUN 1
START OF ENDURANCE
STRIP
RUN 1
RUN 2
RUN 3
RUN 4
RUN 5
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
0.5
200
400
600
800
1000
1200
1400
1600
TEMPERATURE—°F

Figure 58



ETCHANT: MARBLE'S REAGENT MAG: 100X
MICROSTRUCTURE OF LITHIATED AND OXIDIZED NICKEL C
COATING SINTERED ON STAINLESS STEEL, BEFORE TEST

Figure 59



ETCHANT: MARBLE'S REAGENT MAG: 100X
MICROSTRUCTURE OF LITHIATED AND OXIDIZED NICKEL C
COATING SINTERED ON STAINLESS STEEL, AFTER TEST

Figure 60

TOTAL HEMISPHERICAL EMITTANCE vs. TIME

COATING: OXIDIZED AND LITHIATED NICKEL C
SUBSTRATE: AISI-310 STAINLESS STEEL

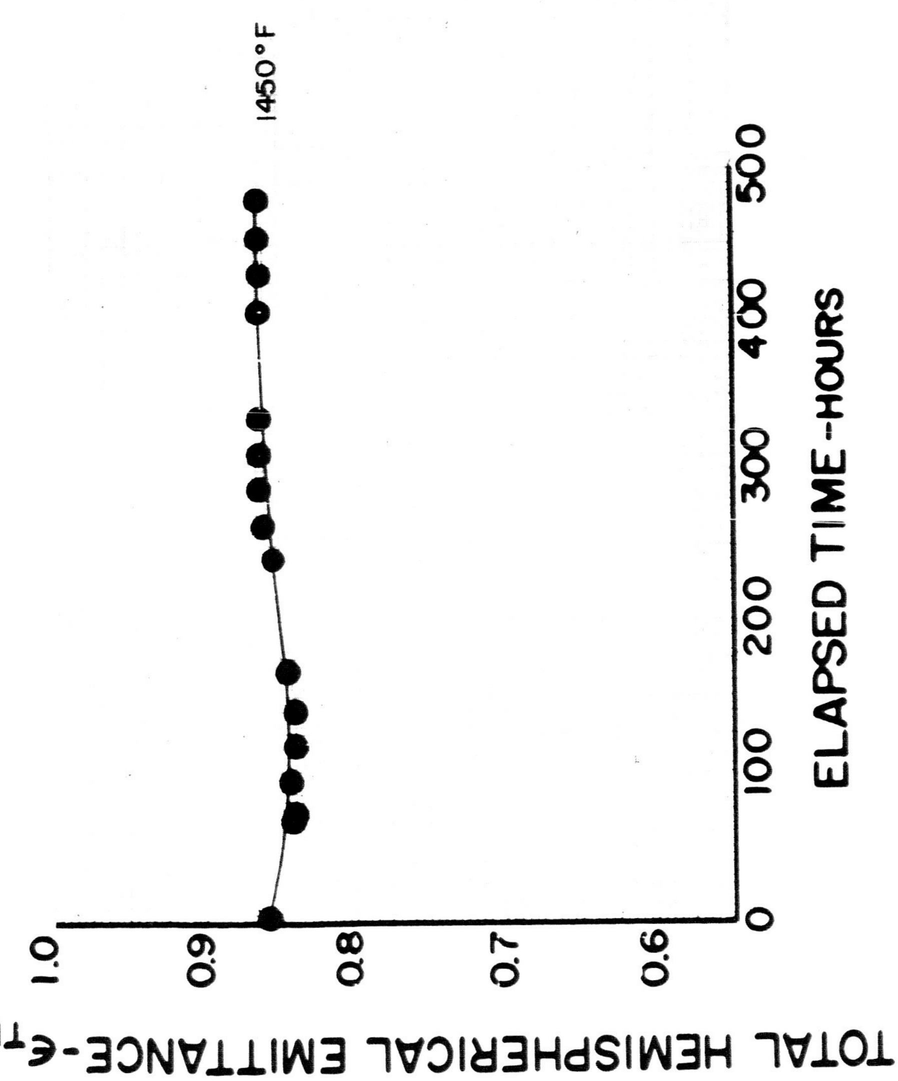


Figure 61

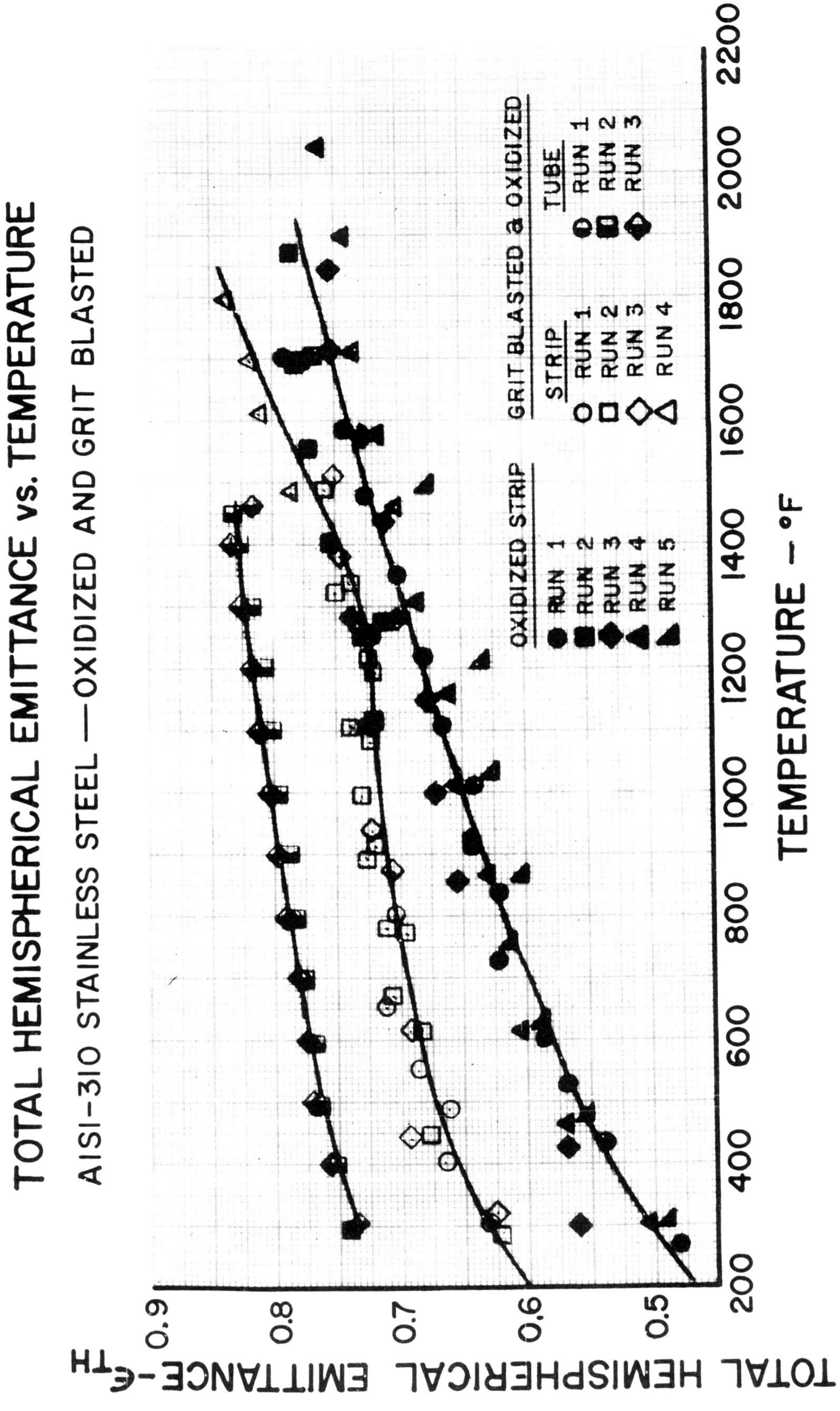
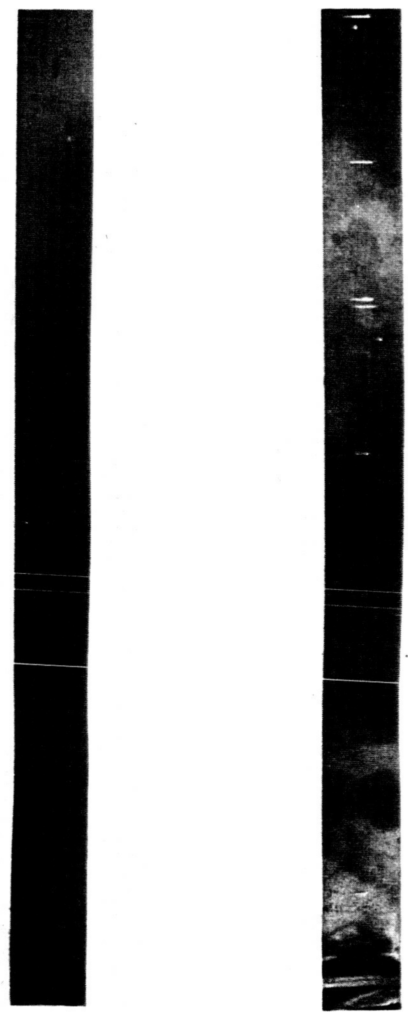
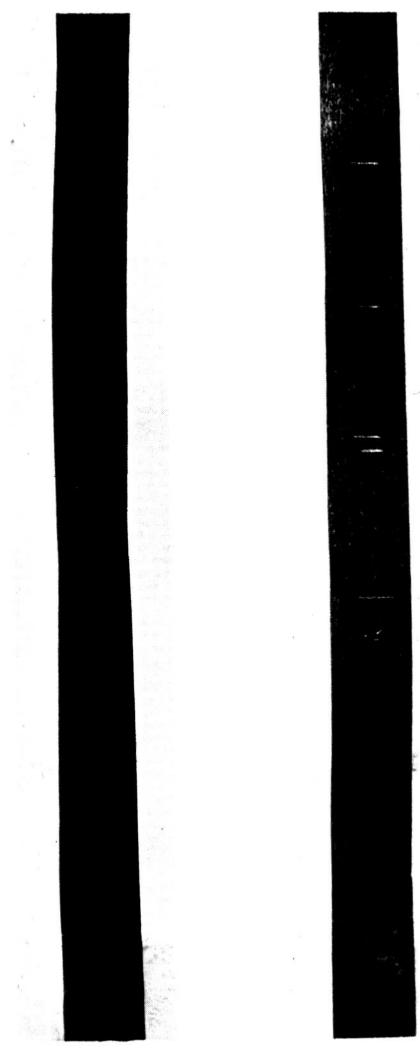

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
AISI-310 STAINLESS STEEL — OXIDIZED AND GRIT BLASTED
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
TEMPERATURE — °F
0.9
0.8
0.7
0.6
0.5
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
OXIDIZED STRIP
RUN 1
RUN 2
RUN 3
RUN 4
RUN 5
GRIT BLASTED & OXIDIZED
STRIP
RUN 1
RUN 2
RUN 3
RUN 4
TUBE
RUN 1
RUN 2
RUN 3

Figure 62



BEFORE AFTER

APPEARANCE OF OXIDIZED AISI- 310 STAINLESS STEEL STRIP BEFORE AND AFTER TESTING

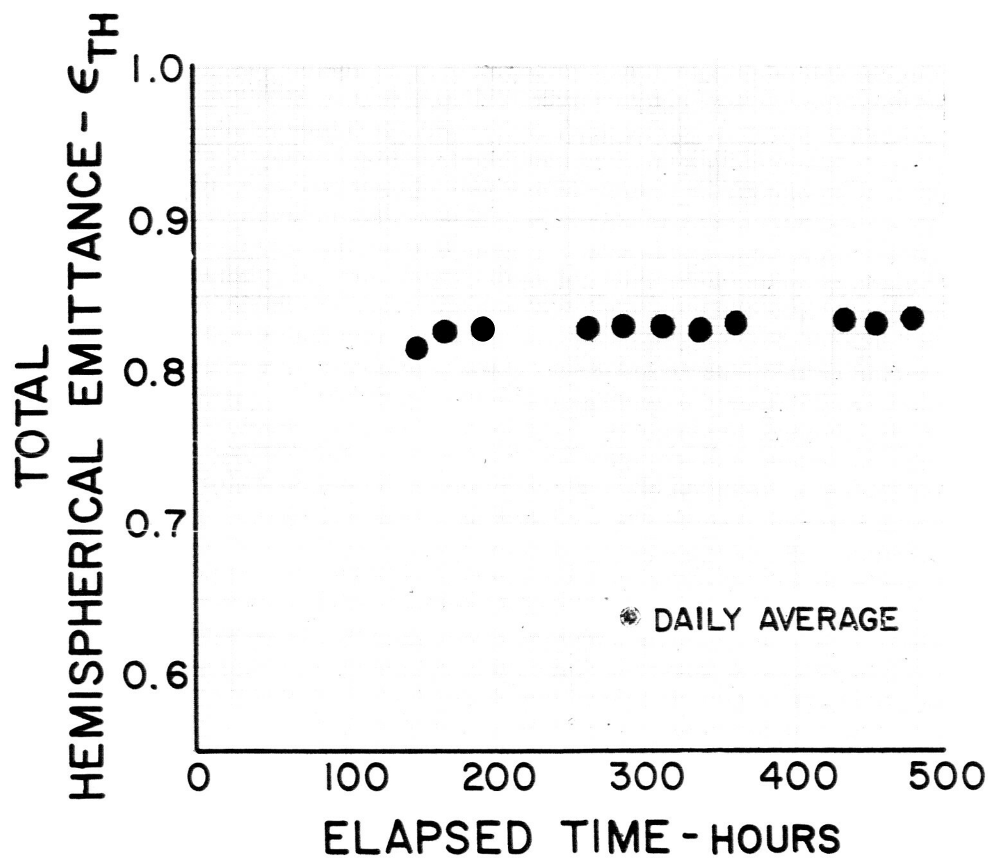


APPEARANCE OF OXIDIZED AND GRIT BLASTED AISI -310 STAINLESS STEEL STRIP BEFORE AND AFTER TESTING

Figure 64

TOTAL HEMISPHERICAL EMITTANCE vs. TIME

AISI-310 STAINLESS STEEL



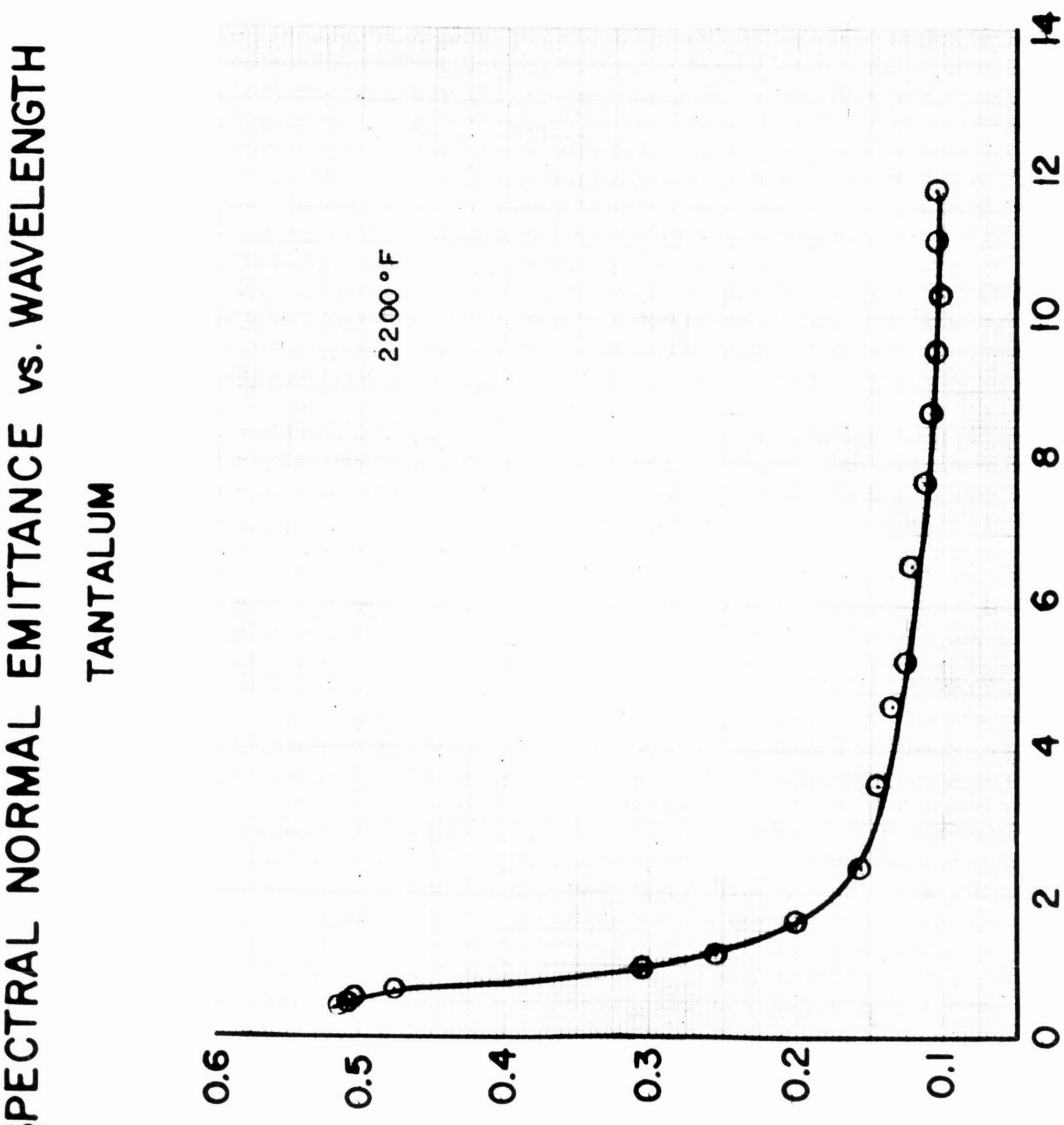

SPECTRAL NORMAL EMITTANCE vs. WAVELENGTH
TANTALUM
2200°F
SPECTRAL NORMAL EMITTANCE — $\epsilon_{\lambda N}$
0.6
0.5
0.4
0.3
0.2
0.1
0
2
4
6
8
10
12
14
WAVELENGTH — λ — MICRONS

Figure 66

SPECTRAL NORMAL EMITTANCE vs. WAVELENGTH

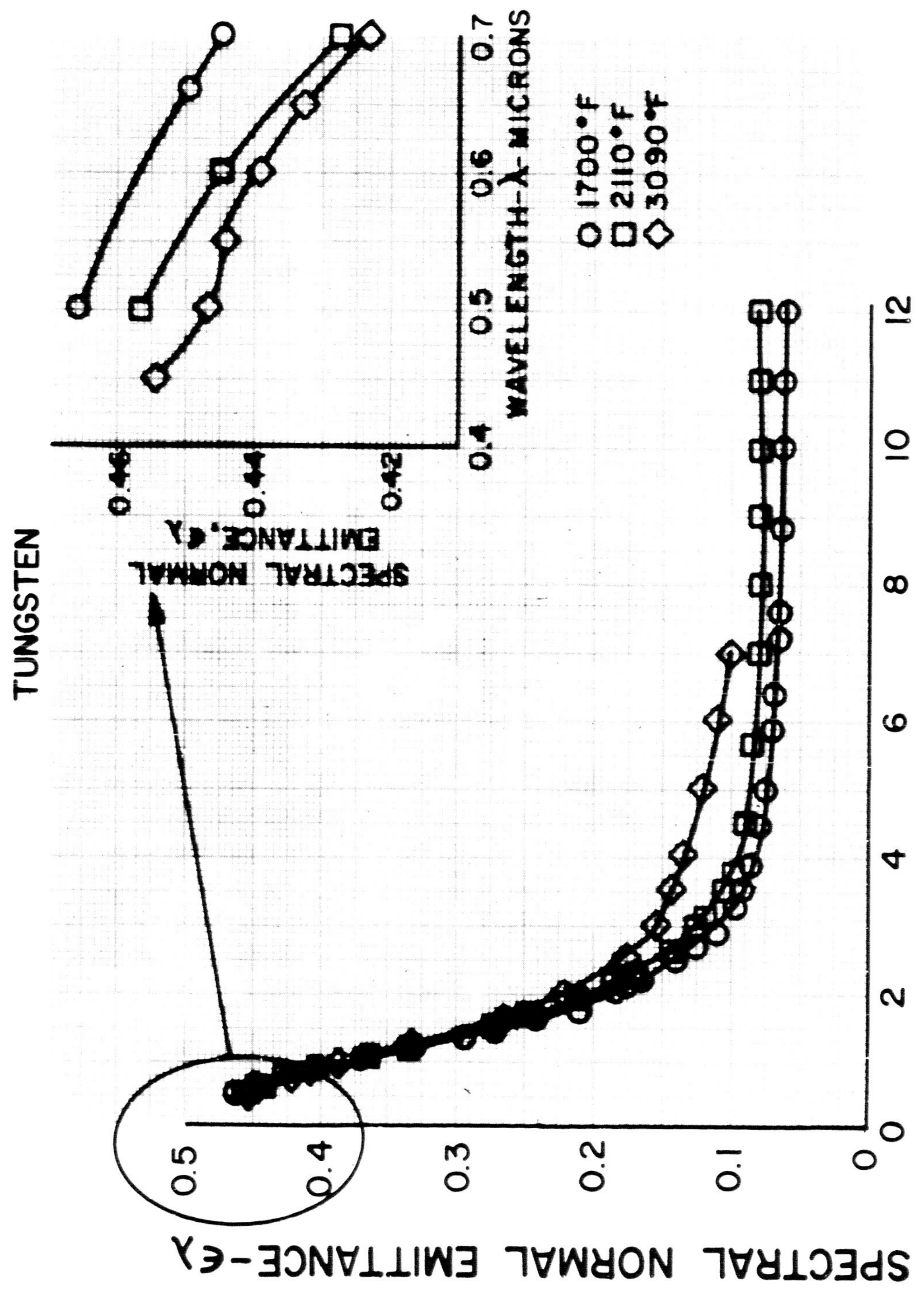


Figure 67

SPECTRAL NORMAL EMITTANCE vs. WAVELENGTH

TUNGSTEN

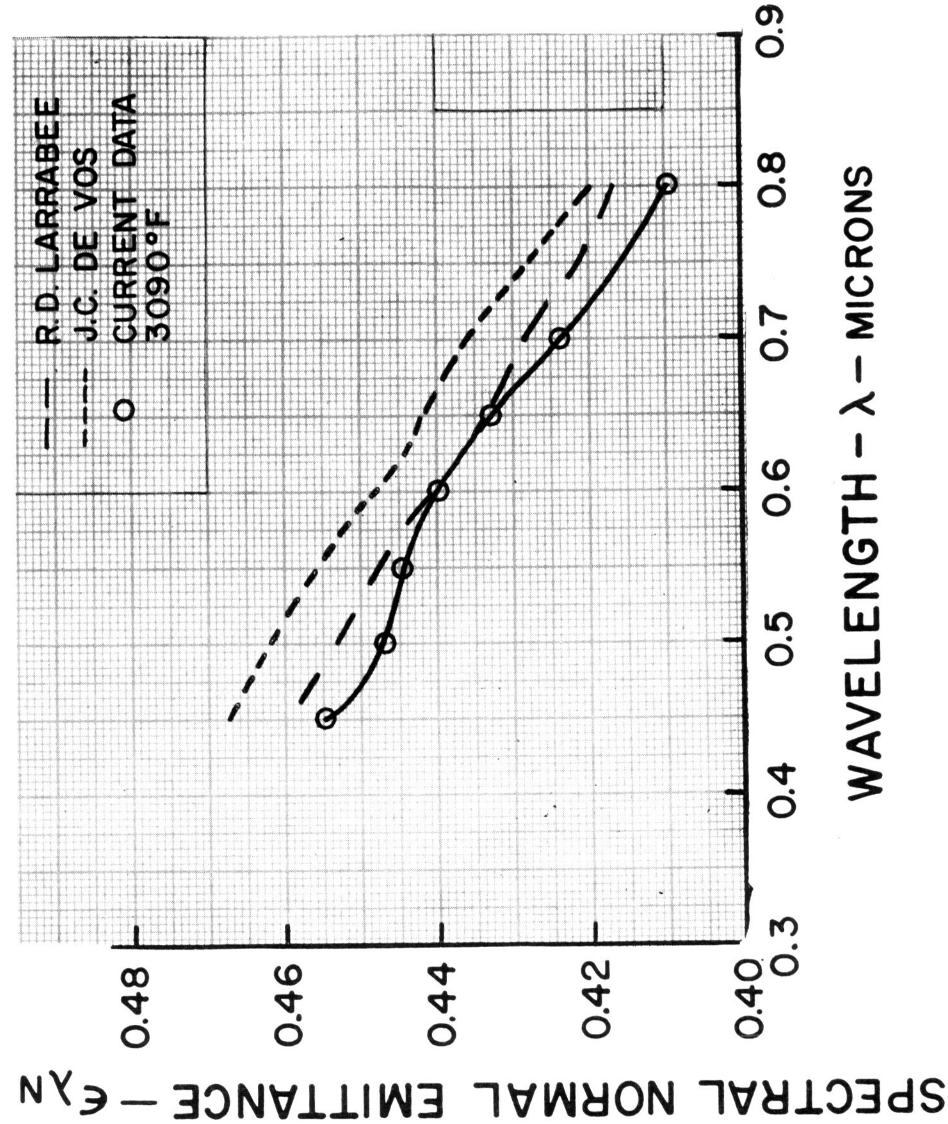


Figure 68

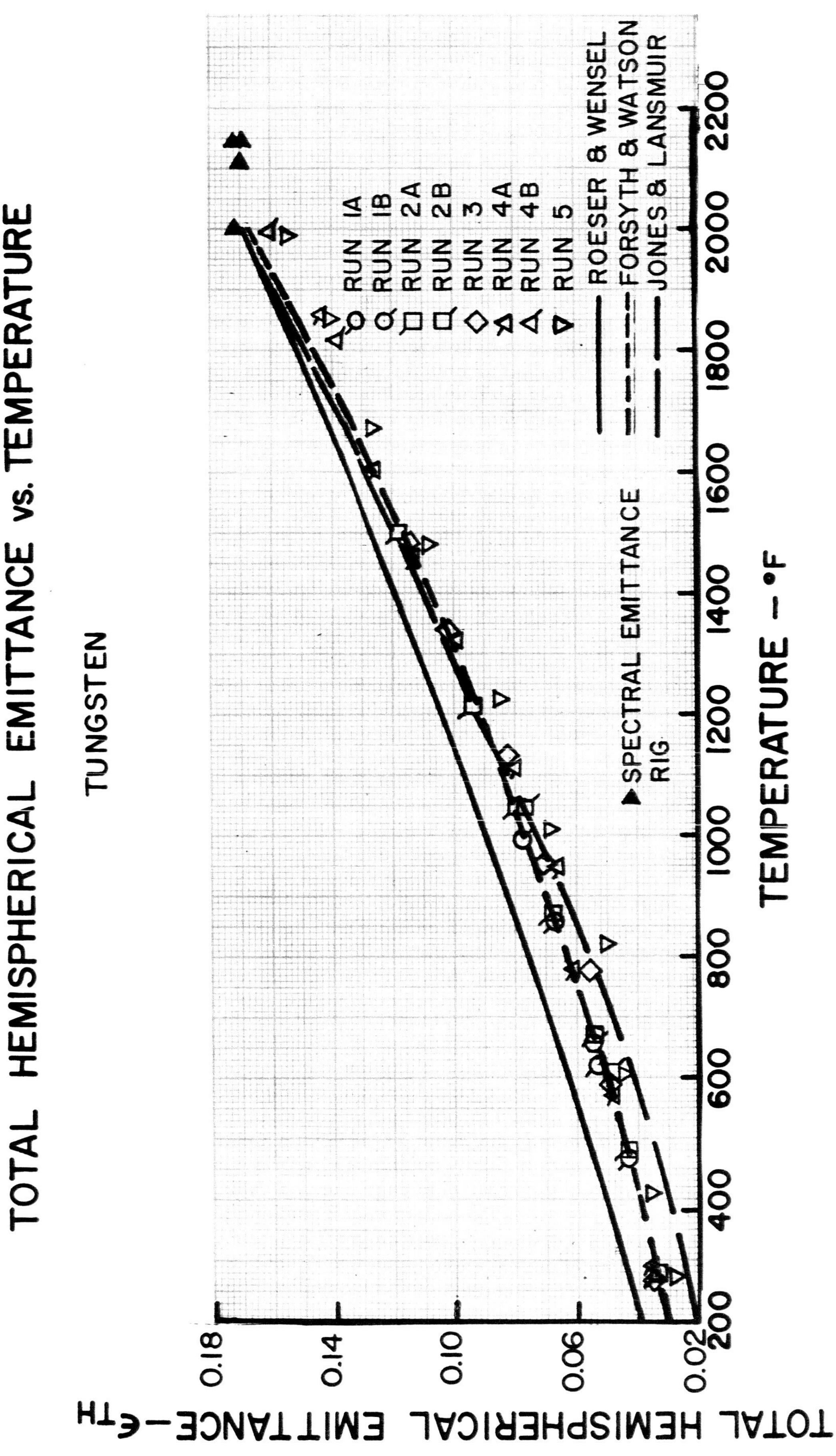

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
TUNGSTEN
RUN 1A
RUN 1B
RUN 2A
RUN 2B
RUN 3
RUN 4A
RUN 4B
RUN 5
ROESER & WENSEL
FORSYTH & WATSON
JONES & LANSMUIR
SPECTRAL EMITTANCE RIG
TOTAL HEMISPHERICAL EMITTANCE—ϵ_{TH}
0.02
0.06
0.10
0.14
0.18
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 69

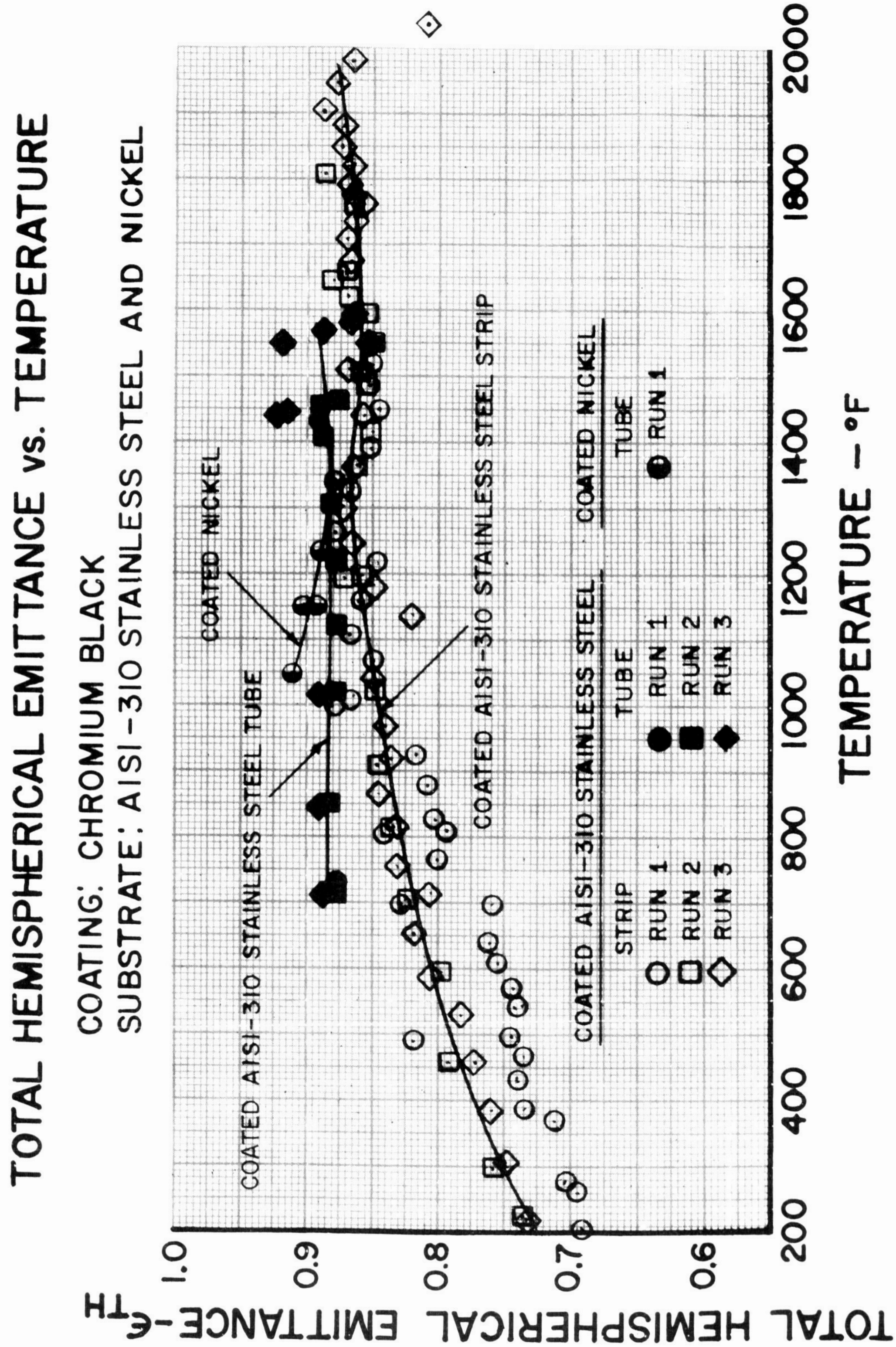

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: CHROMIUM BLACK
SUBSTRATE: AISI-310 STAINLESS STEEL AND NICKEL
COATED NICKEL
COATED AISI-310 STAINLESS STEEL TUBE
COATED AISI-310 STAINLESS STEEL STRIP
COATED AISI-310 STAINLESS STEEL
STRIP
RUN 1
RUN 2
RUN 3
TUBE
RUN 1
RUN 2
RUN 3
COATED NICKEL
TUBE
RUN 1
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
TEMPERATURE — °F

Figure 70

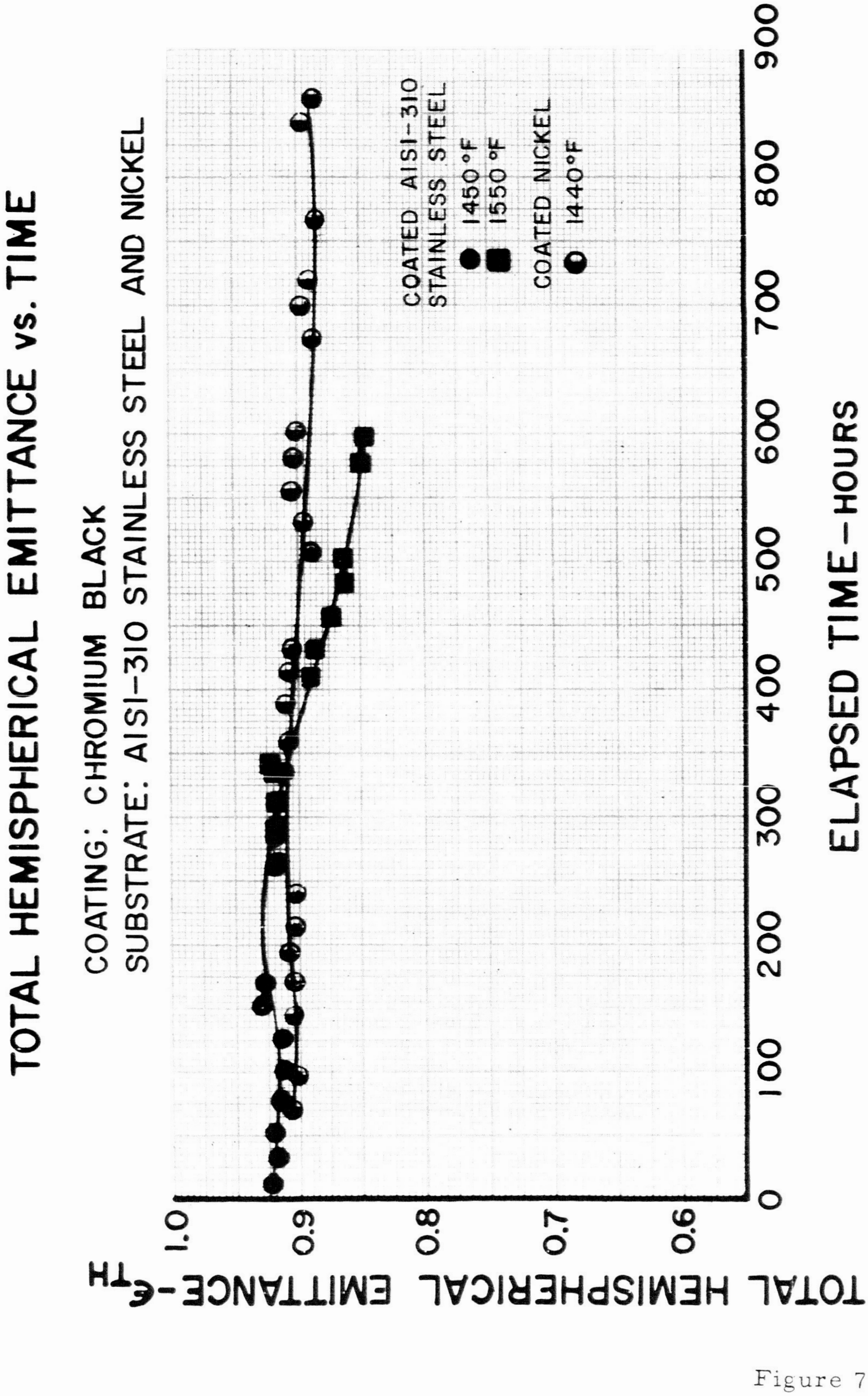

TOTAL HEMISPHERICAL EMITTANCE vs. TIME
COATING: CHROMIUM BLACK
SUBSTRATE: AISI-310 STAINLESS STEEL AND NICKEL
COATED AISI-310 STAINLESS STEEL
1450 °F
1550 °F
COATED NICKEL
1440 °F
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
0
100
200
300
400
500
600
700
800
900
ELAPSED TIME-HOURS

Figure 71

SPECTRAL NORMAL EMITTANCE vs. WAVELENGTH

COATING: CHROMIUM BLACK
SUBSTRATE: AISI - 310 STAINLESS STEEL

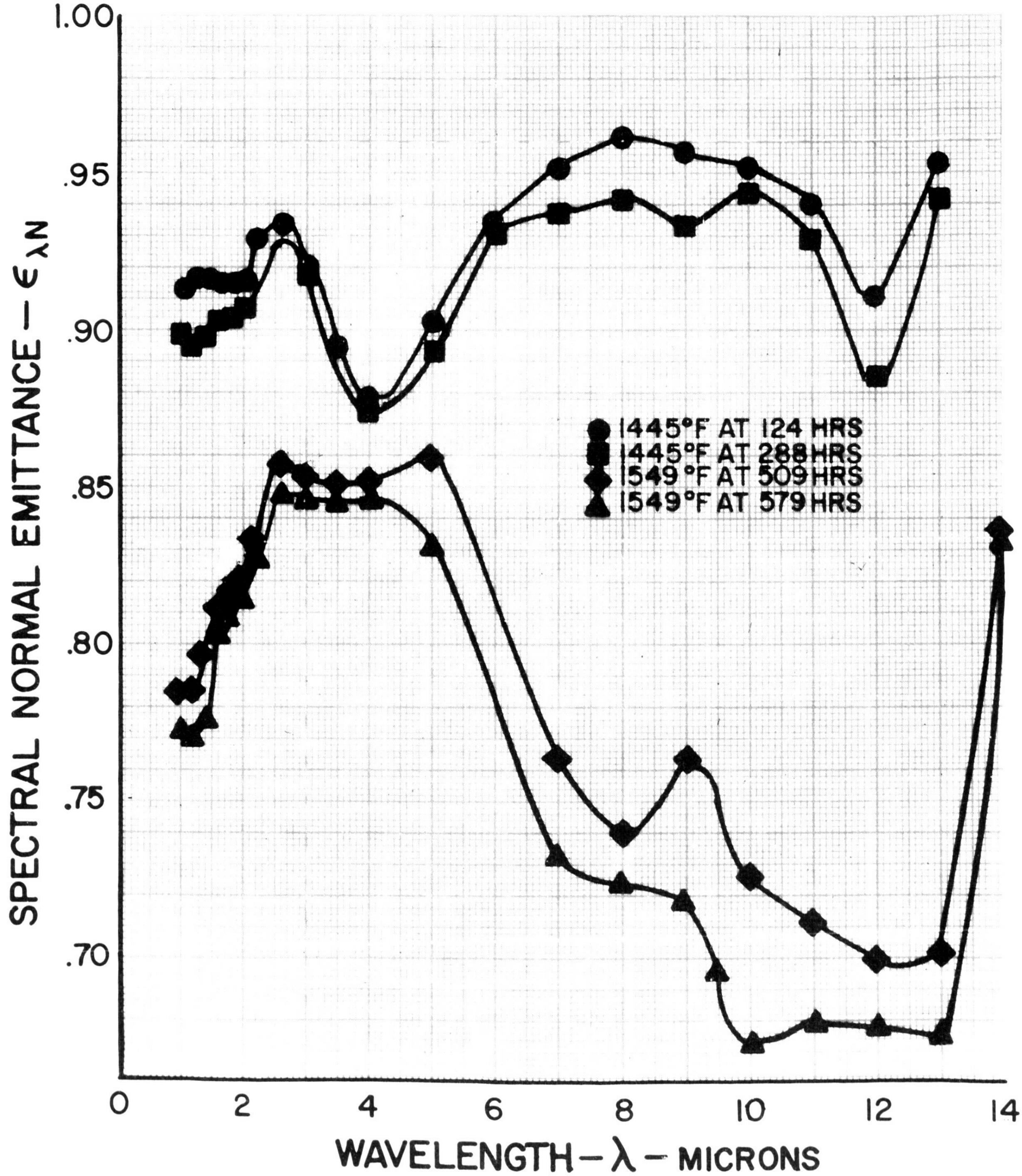


Figure 72

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE

COATING: PLATINUM BLACK
SUBSTRATE: AISI-310 STAINLESS STEEL

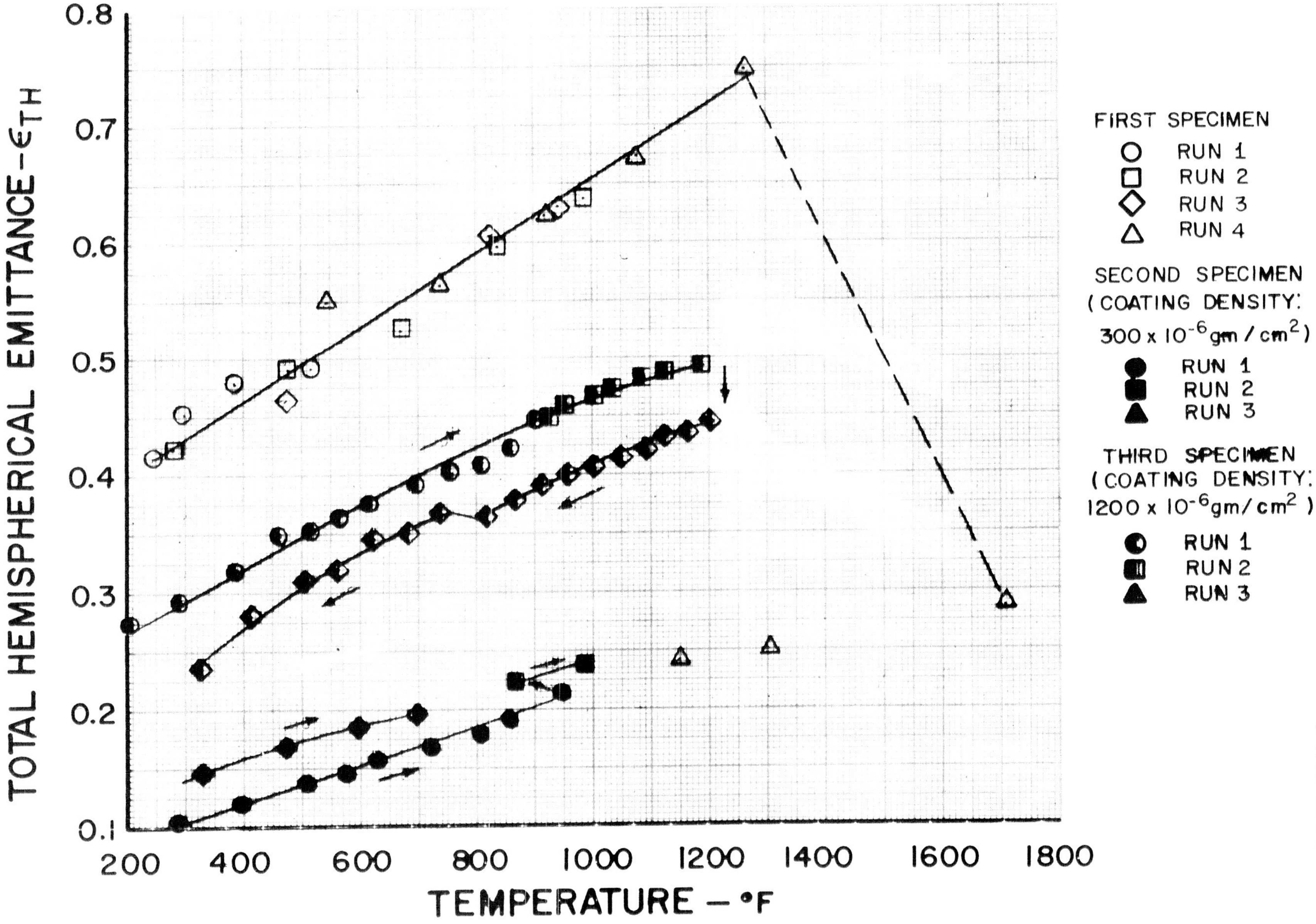
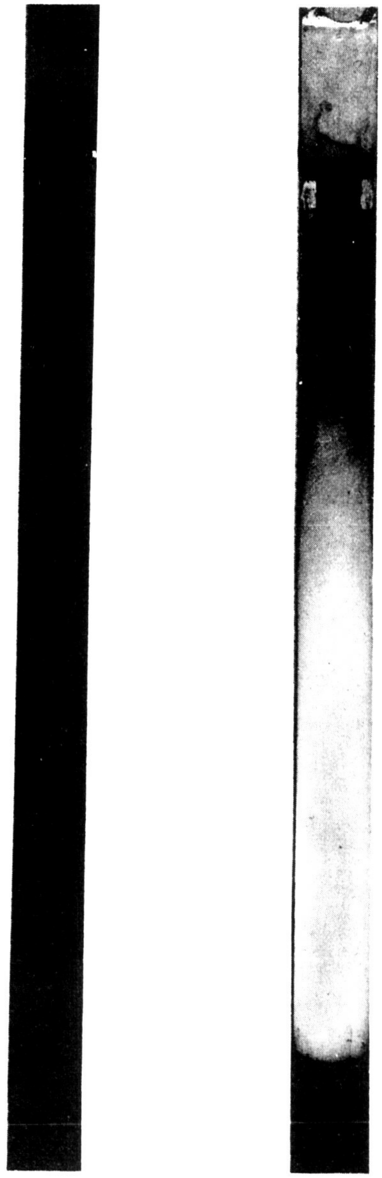


Figure 73



BEFORE AFTER

APPEARANCE OF AISI-310 STAINLESS STEEL STRIP COATED WITH PLATINUM BLACK BEFORE AND AFTER TESTING

Figure 74

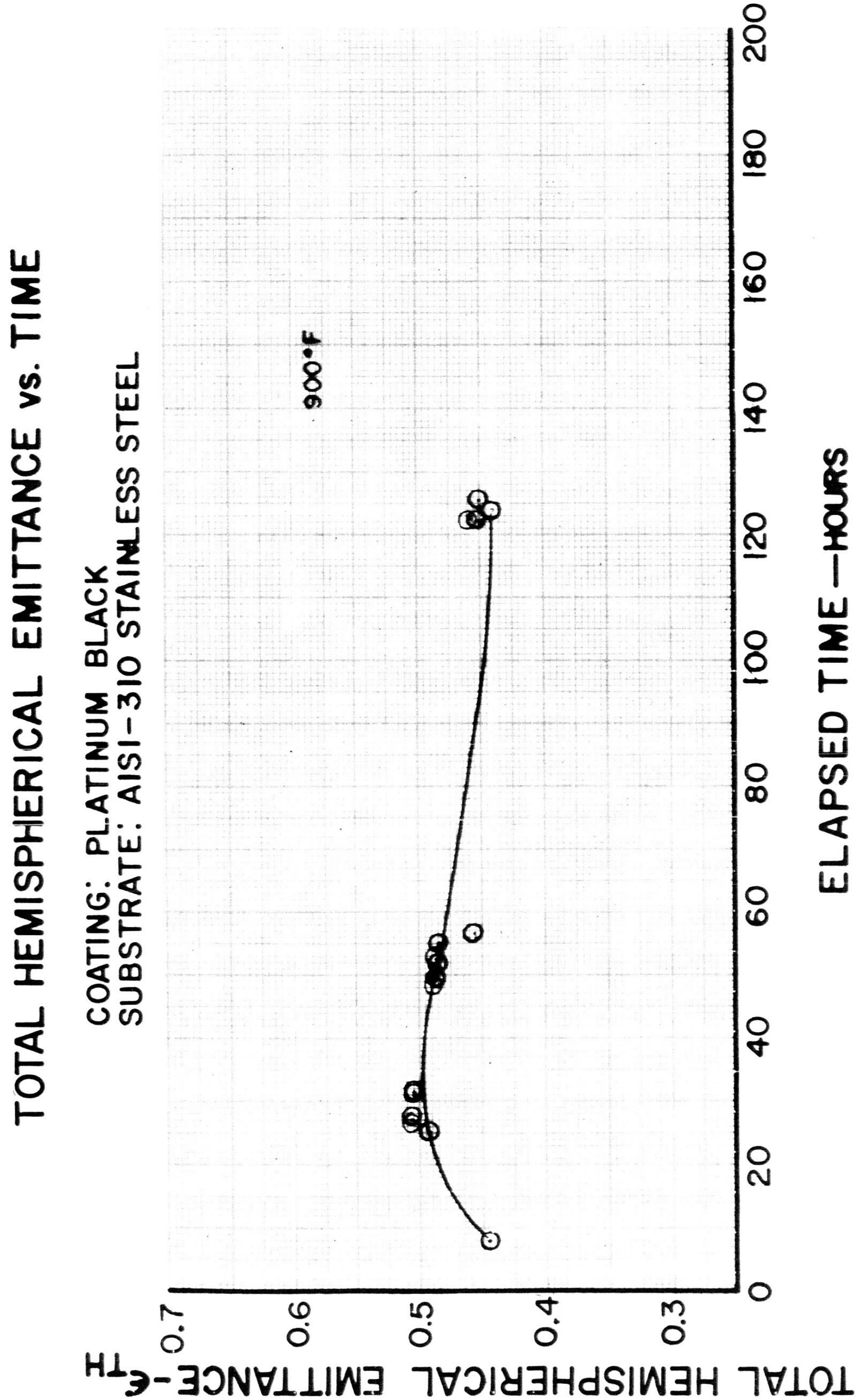

TOTAL HEMISPHERICAL EMITTANCE vs. TIME
COATING: PLATINUM BLACK
SUBSTRATE: AISI-310 STAINLESS STEEL
900°F
ELAPSED TIME —HOURS
0
20
40
60
80
100
120
140
160
180
200
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
0.7
0.6
0.5
0.4
0.3

Figure 75

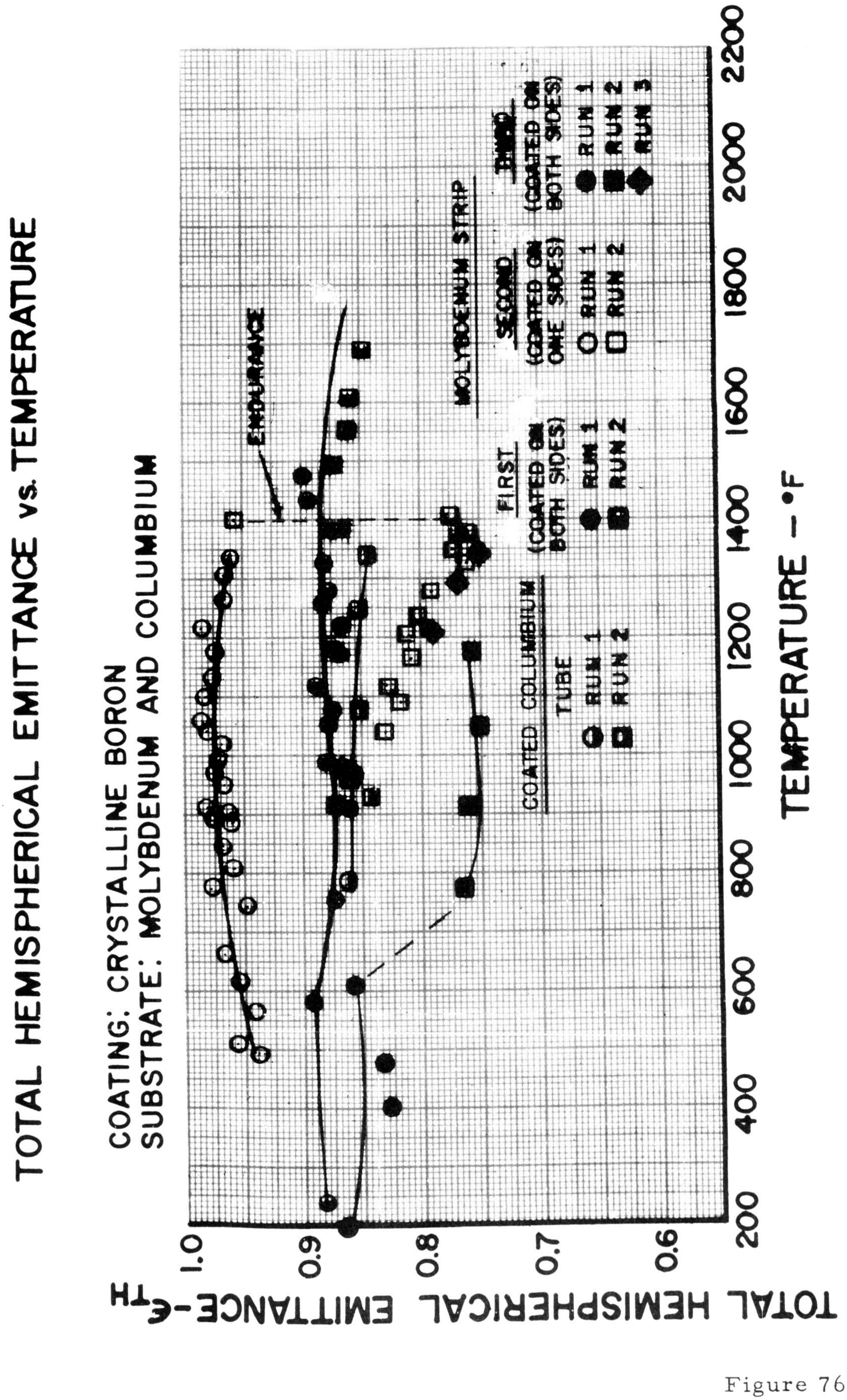

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: CRYSTALLINE BORON
SUBSTRATE: MOLYBDENUM AND COLUMBIUM
ENDURANCE
MOLYBDENUM STRIP
FIRST
(COATED ON BOTH SIDES)
RUN 1
RUN 2
SECOND
(COATED ON ONE SIDES)
RUN 1
RUN 2
THIRD
(COATED ON BOTH SIDES)
RUN 1
RUN 2
RUN 3
COATED COLUMBIUM TUBE
RUN 1
RUN 2
TEMPERATURE — °F
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6

Figure 76

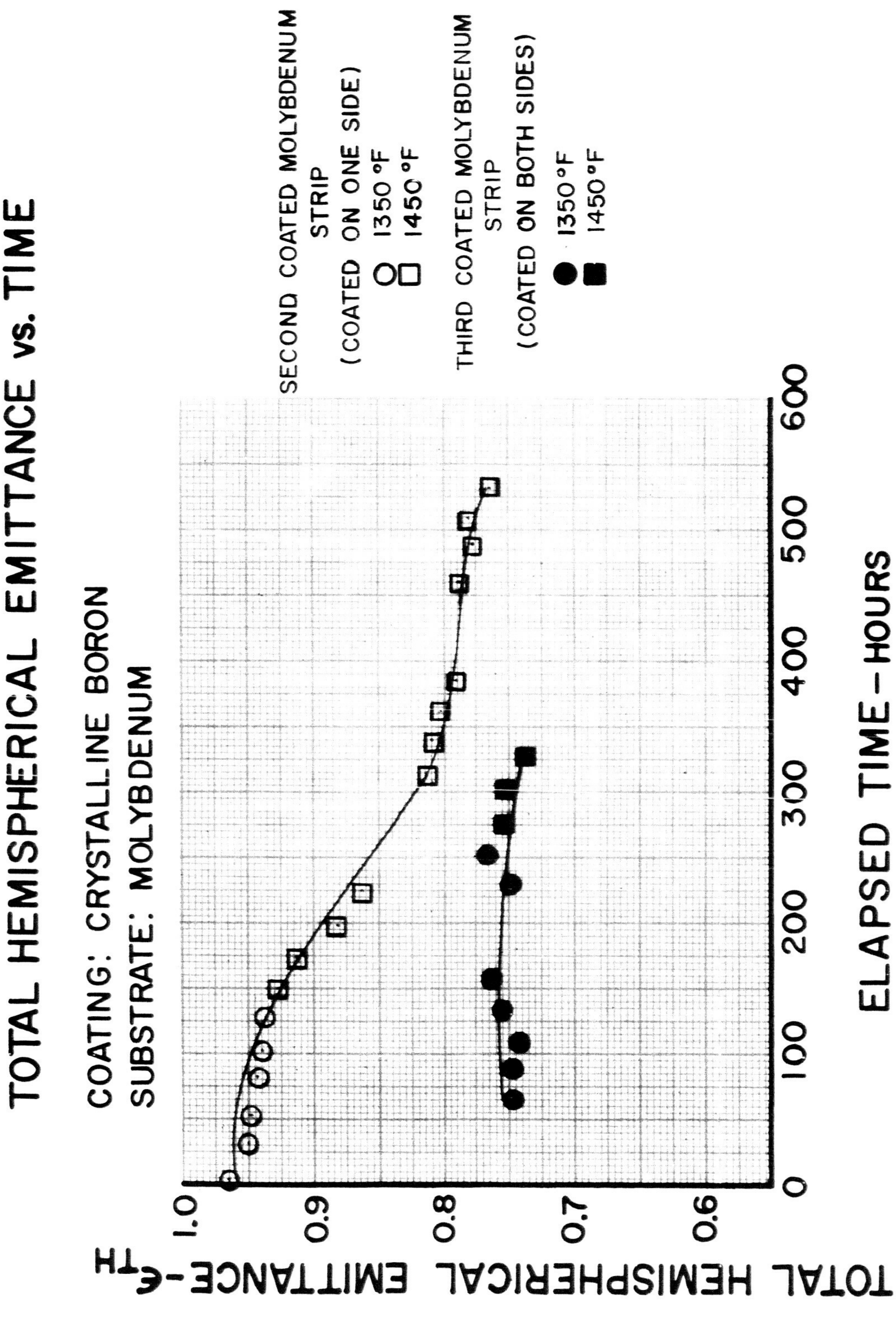
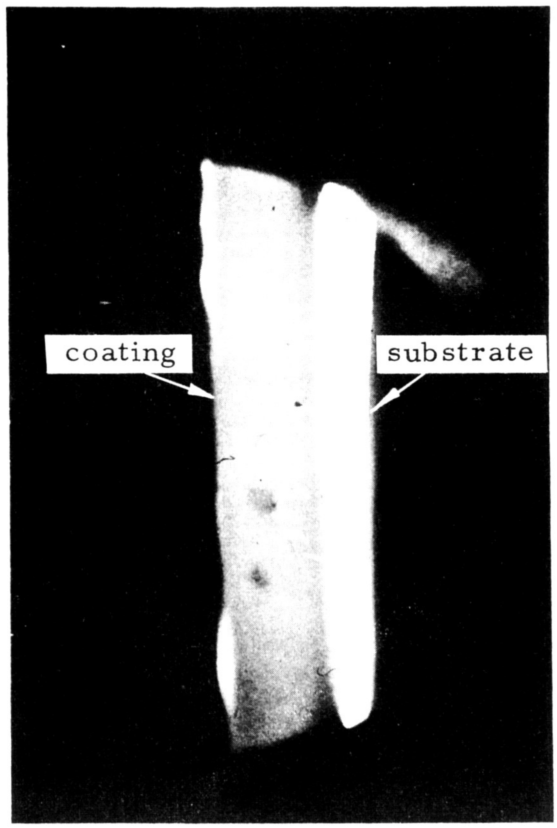

TOTAL HEMISPHERICAL EMITTANCE vs. TIME
COATING: CRYSTALLINE BORON
SUBSTRATE: MOLYBDENUM
SECOND COATED MOLYBDENUM STRIP
(COATED ON ONE SIDE)
1350 °F
1450 °F
THIRD COATED MOLYBDENUM STRIP
(COATED ON BOTH SIDES)
1350 °F
1450 °F
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
0
100
200
300
400
500
600
ELAPSED TIME-HOURS

Figure 77



BONDING FAILURE OF BORON
COATING ON MOLYBDENUM STRIP

Figure 78

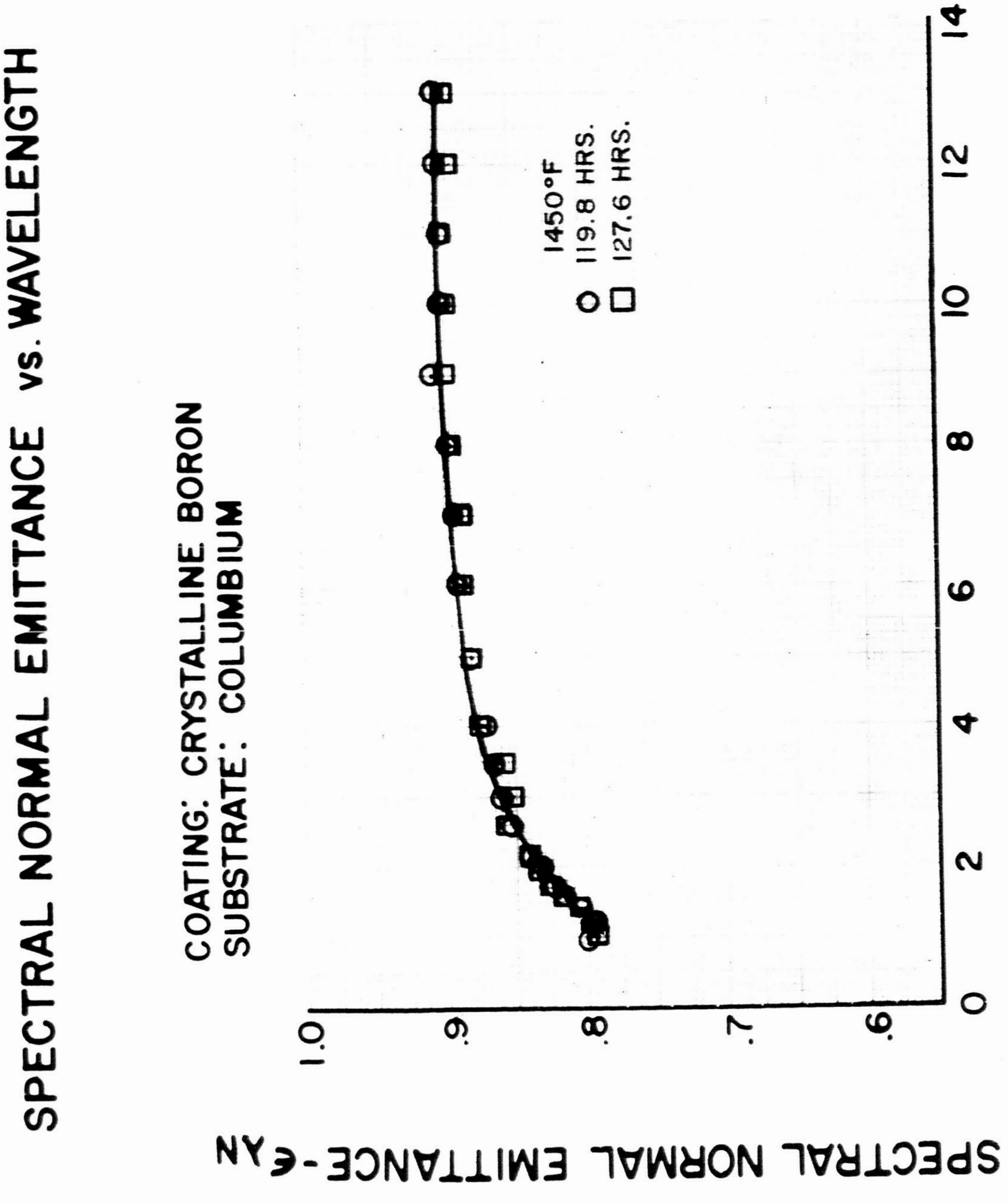
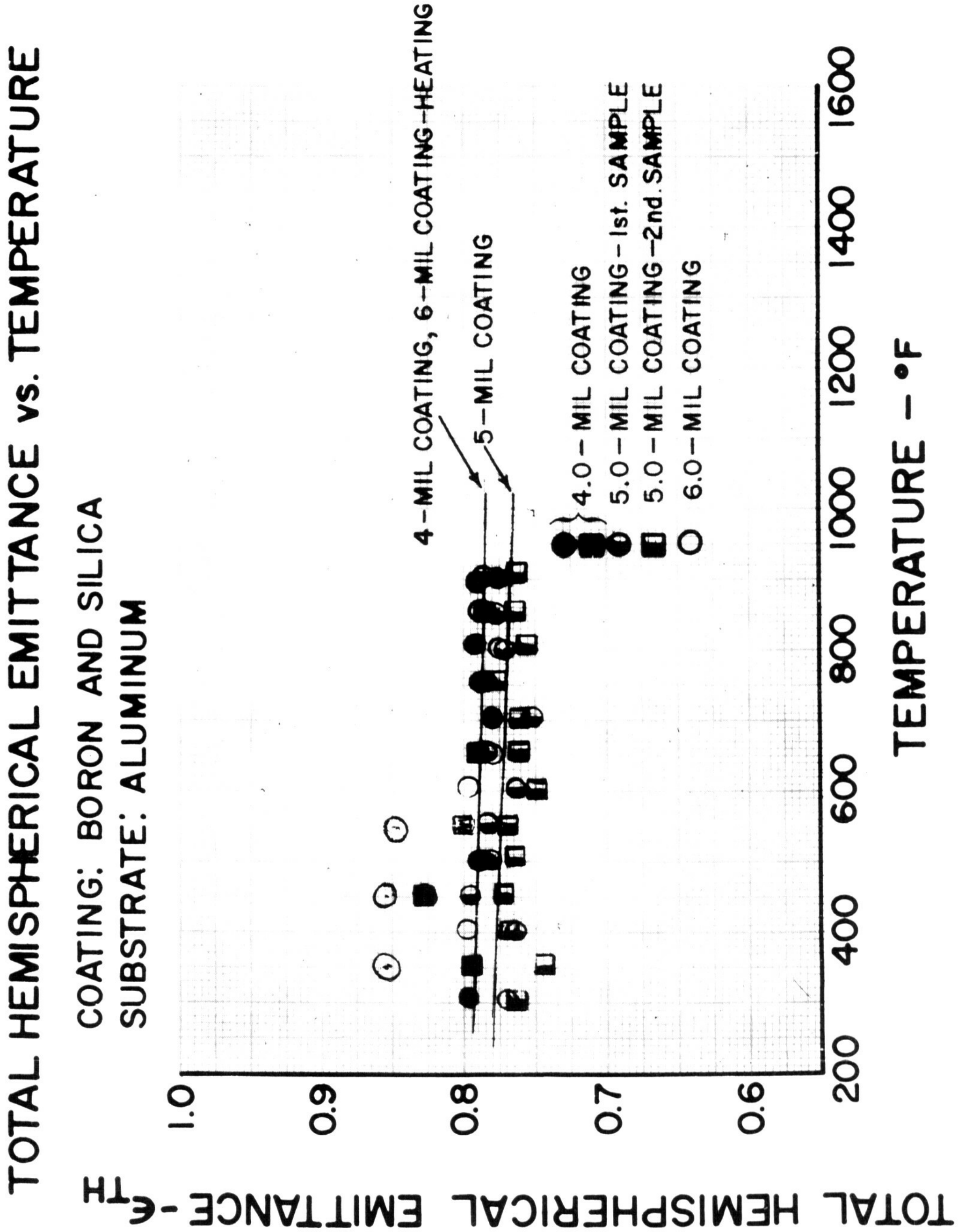

SPECTRAL NORMAL EMITTANCE vs. WAVELENGTH
COATING: CRYSTALLINE BORON
SUBSTRATE: COLUMBIUM
1450°F
○ 119.8 HRS.
□ 127.6 HRS.
1.0
.9
.8
.7
.6
SPECTRAL NORMAL EMITTANCE - $\epsilon_{\lambda N}$
0
2
4
6
8
10
12
14
WAVELENGTH - λ - MICRONS

Figure 79



TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: BORON AND SILICA
SUBSTRATE: ALUMINUM
4-MIL COATING, 6-MIL COATING-HEATING
5-MIL COATING
4.0 - MIL COATING
5.0 - MIL COATING - Ist. SAMPLE
5.0 - MIL COATING -2nd. SAMPLE
6.0 - MIL COATING
TOTAL HEMISPHERICAL EMITTANCE -ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
TEMPERATURE - °F

Figure 80

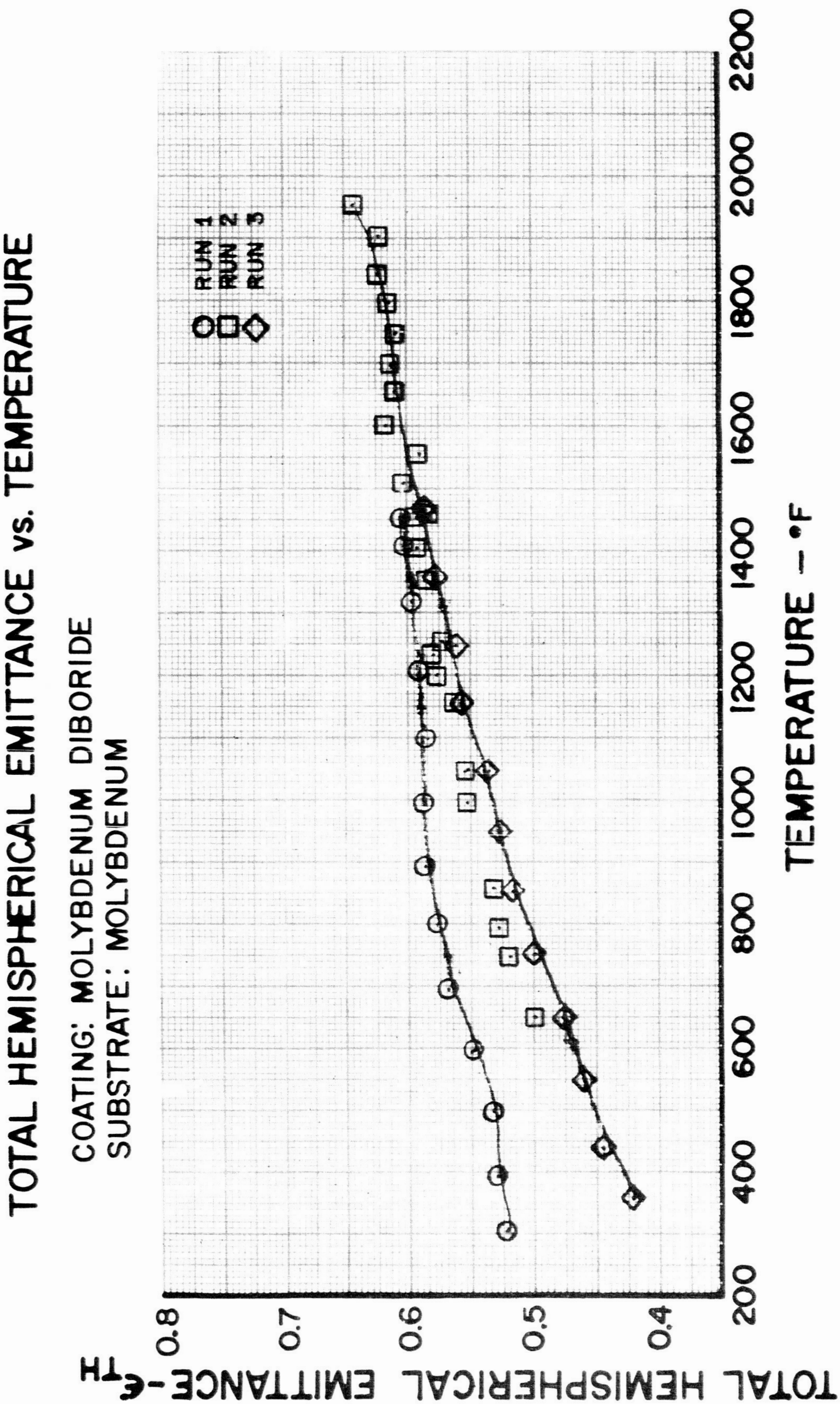

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: MOLYBDENUM DIBORIDE
SUBSTRATE: MOLYBDENUM
RUN 1
RUN 2
RUN 3
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
0.8
0.7
0.6
0.5
0.4
TEMPERATURE — °F
200
400
600
800
1000
1200
1400
1600
1800
2000
2200

Figure 81

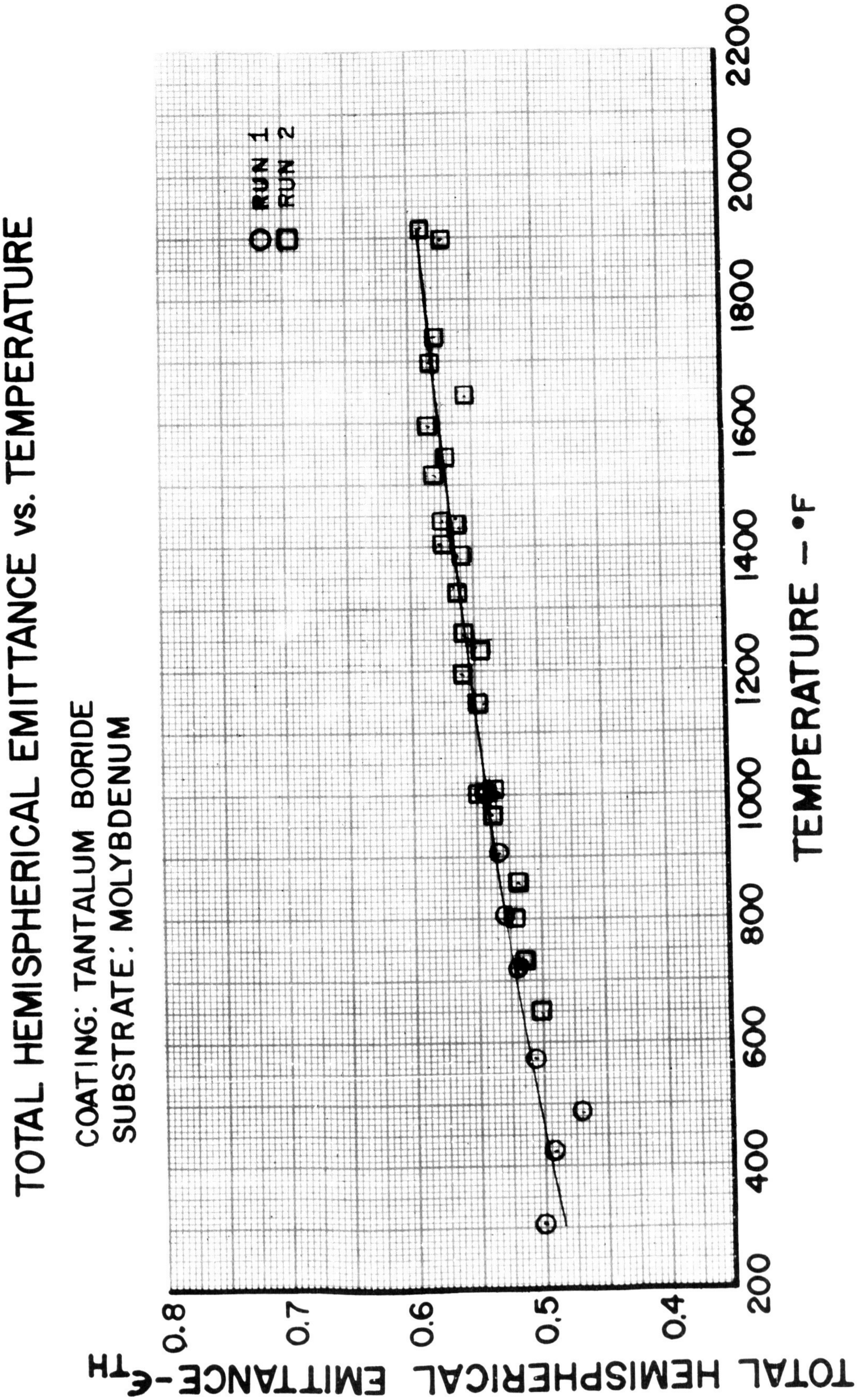

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: TANTALUM BORIDE
SUBSTRATE: MOLYBDENUM
RUN 1
RUN 2
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
0.8
0.7
0.6
0.5
0.4
TEMPERATURE — °F
200
400
600
800
1000
1200
1400
1600
1800
2000
2200

Figure 82

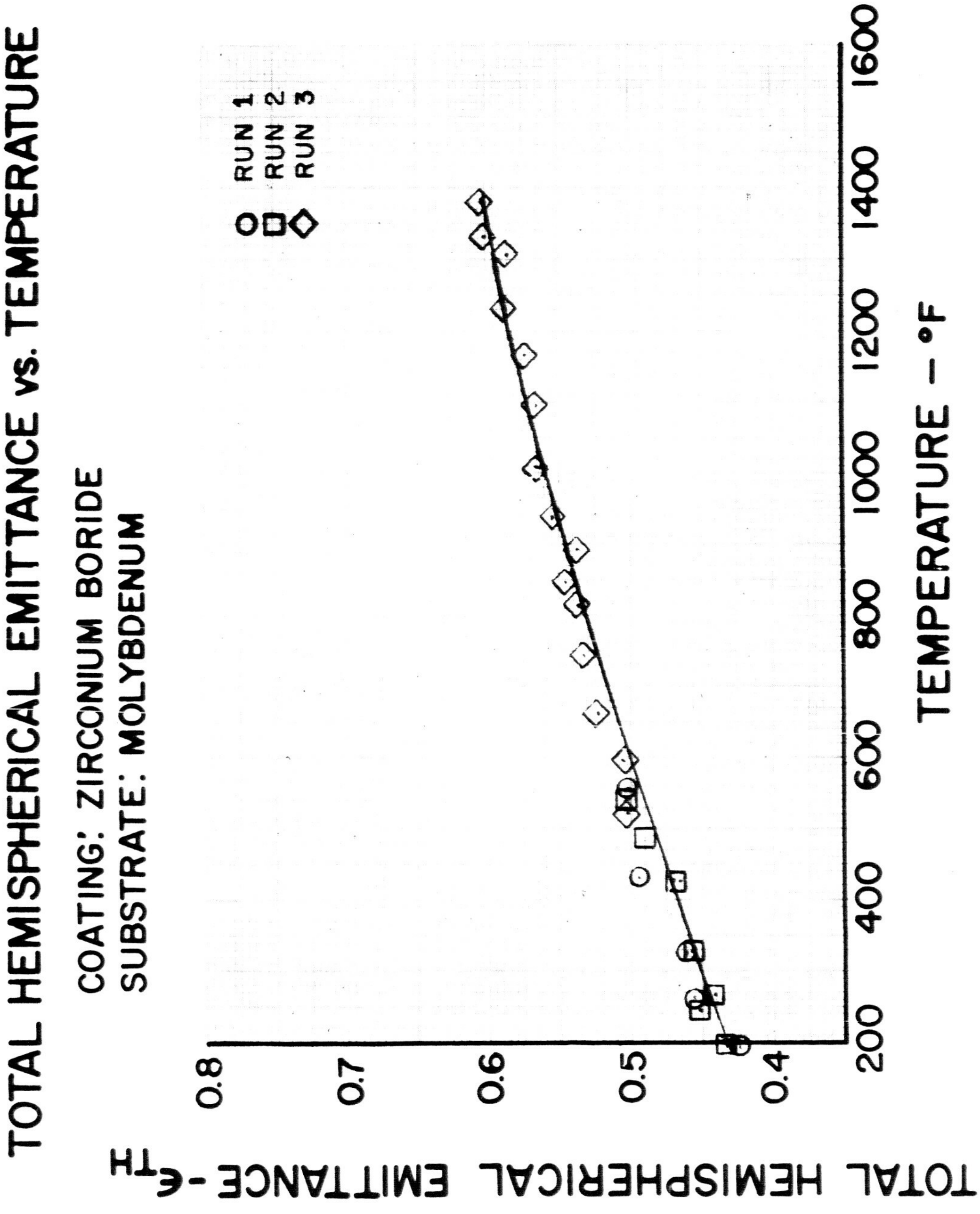

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: ZIRCONIUM BORIDE
SUBSTRATE: MOLYBDENUM
RUN 1
RUN 2
RUN 3
0.8
0.7
0.6
0.5
0.4
200
400
600
800
1000
1200
1400
1600
TEMPERATURE — °F
TOTAL HEMISPHERICAL EMITTANCE -ϵ_{TH}

Figure 83

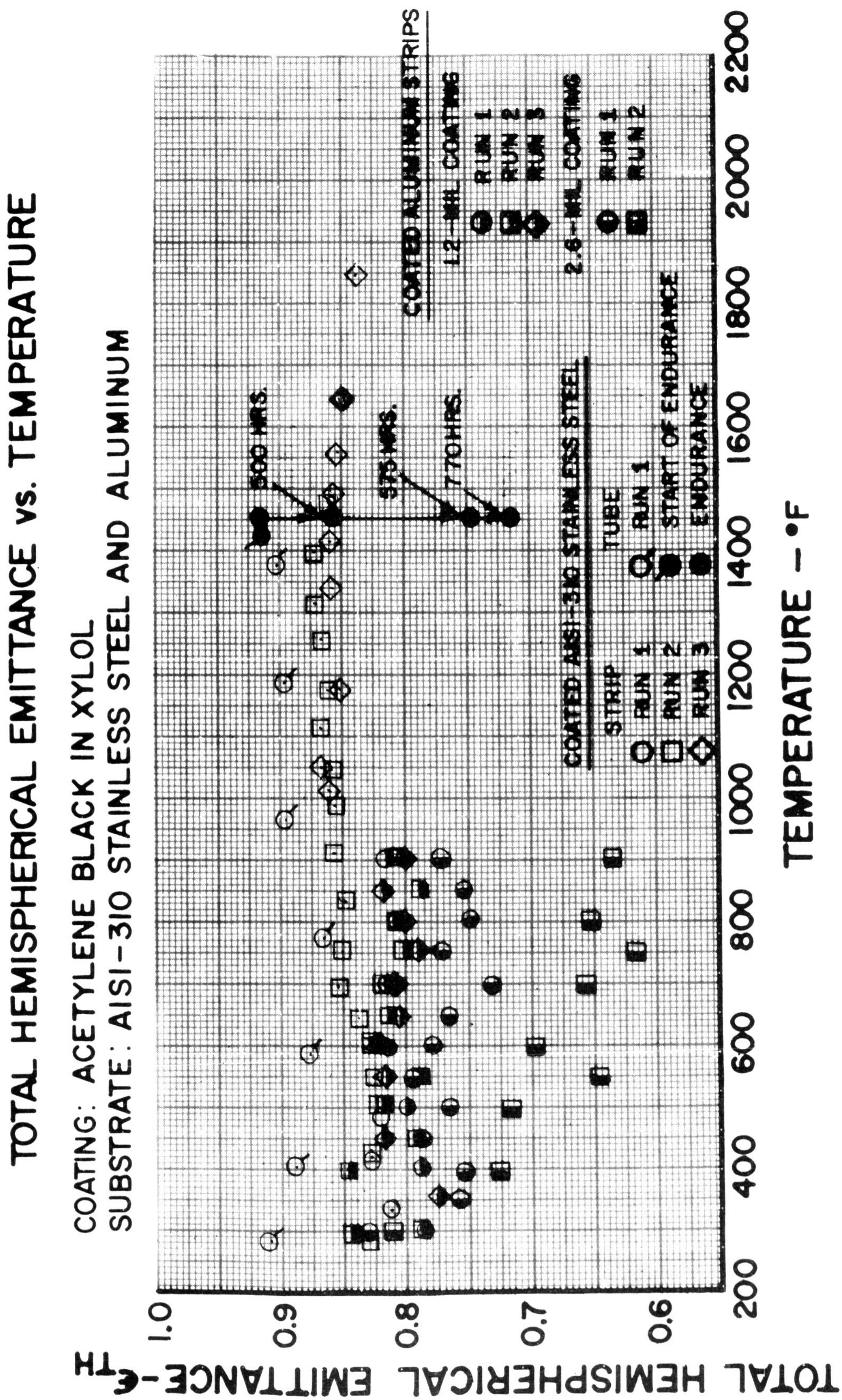

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: ACETYLENE BLACK IN XYLOL
SUBSTRATE: AISI-310 STAINLESS STEEL AND ALUMINUM
TOTAL HEMISPHERICAL EMITTANCE-ε_TH
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F
500 HRS.
575 HRS.
770 HRS.
COATED AISI-310 STAINLESS STEEL
STRIP
RUN 1
RUN 2
RUN 3
TUBE
RUN 1
START OF ENDURANCE
ENDURANCE
COATED ALUMINUM STRIPS
1.2-MIL COATING
RUN 1
RUN 2
RUN 3
2.6-MIL COATING
RUN 1
RUN 2

Figure 84

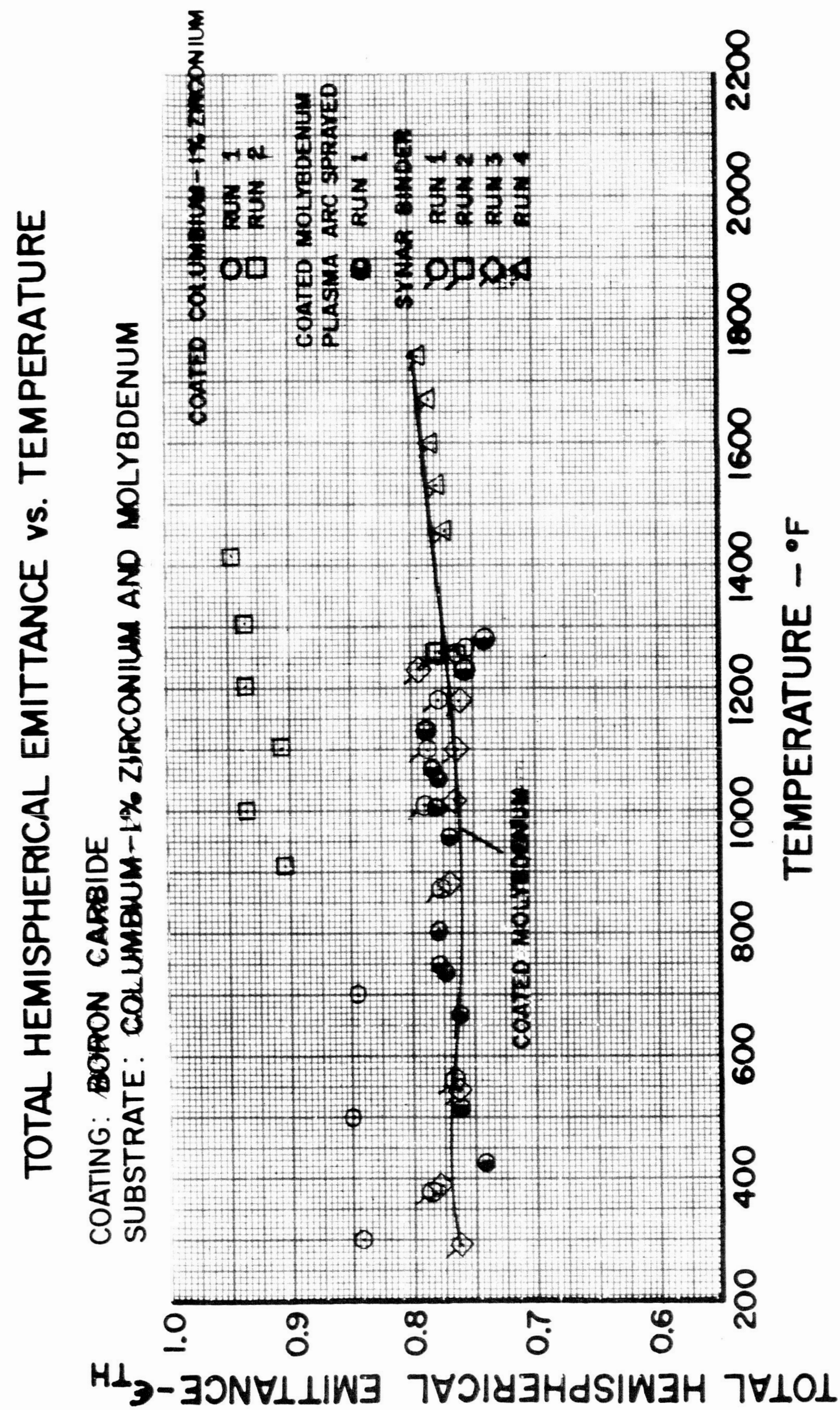

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: BORON CARBIDE
SUBSTRATE: COLUMBIUM-1% ZIRCONIUM AND MOLYBDENUM
COATED COLUMBIUM-1% ZIRCONIUM
RUN 1
RUN 2
COATED MOLYBDENUM
PLASMA ARC SPRAYED
RUN 1
SYNAR BINDER
RUN 1
RUN 2
RUN 3
RUN 4
COATED MOLYBDENUM
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 85

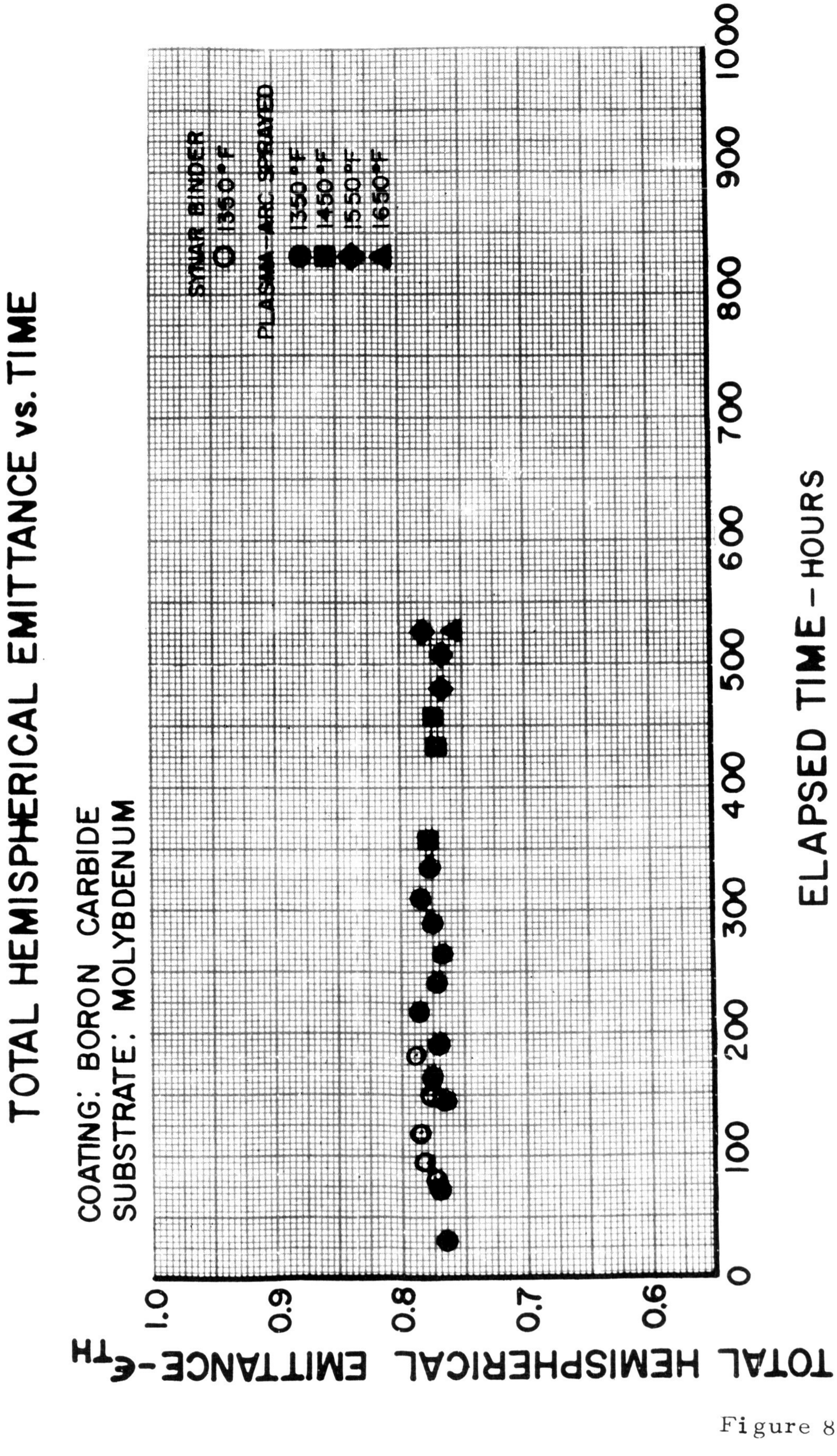

TOTAL HEMISPHERICAL EMITTANCE vs. TIME
COATING: BORON CARBIDE
SUBSTRATE: MOLYBDENUM
SYNAR BINDER
1350°F
PLASMA-ARC SPRAYED
1350°F
1450°F
1550°F
1650°F
0
100
200
300
400
500
600
700
800
900
1000
ELAPSED TIME - HOURS
1.0
0.9
0.8
0.7
0.6
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}

Figure 86

SPECTRAL NORMAL EMITTANCE vs. WAVELENGTH

COATING: BORON CARBIDE
SUBSTRATE: COLUMBIUM — 1% ZIRCONIUM

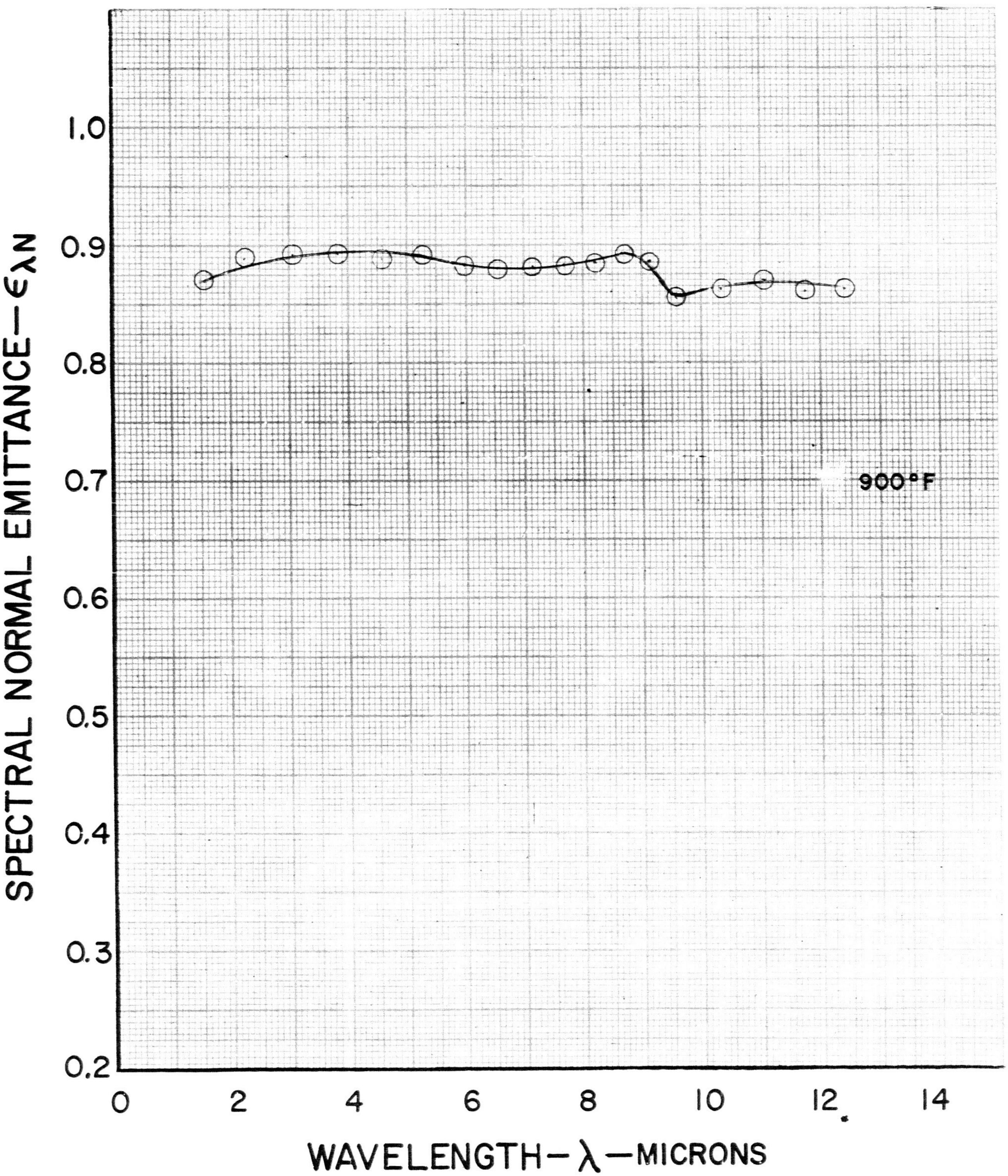


Figure 87

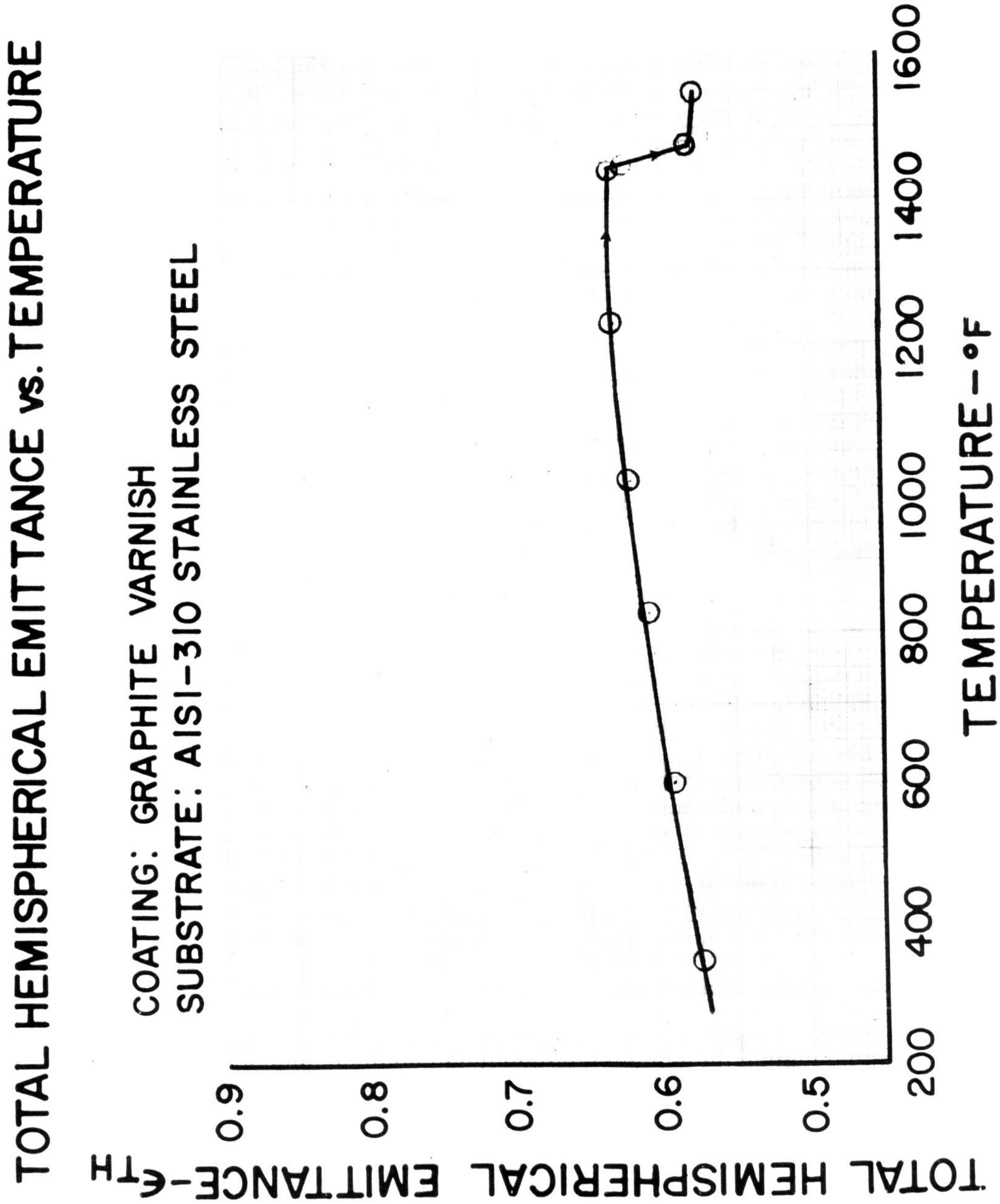

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: GRAPHITE VARNISH
SUBSTRATE: AISI-310 STAINLESS STEEL
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
0.9
0.8
0.7
0.6
0.5
200
400
600
800
1000
1200
1400
1600
TEMPERATURE — °F

Figure 88

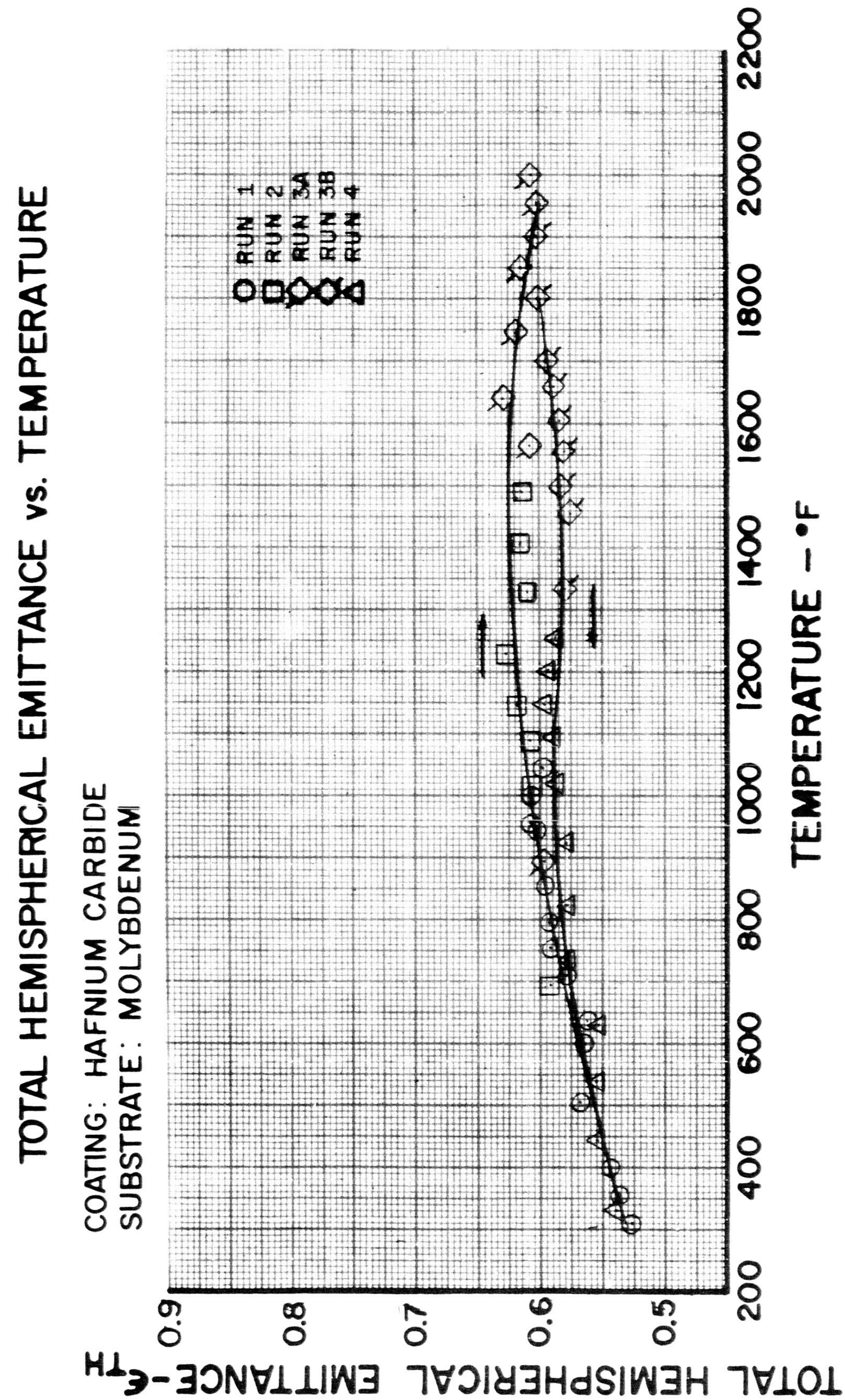

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: HAFNIUM CARBIDE
SUBSTRATE: MOLYBDENUM
RUN 1
RUN 2
RUN 3A
RUN 3B
RUN 4
TOTAL HEMISPHERICAL EMITTANCE-ε TH
0.9
0.8
0.7
0.6
0.5
TEMPERATURE — °F
200
400
600
800
1000
1200
1400
1600
1800
2000
2200

Figure 89

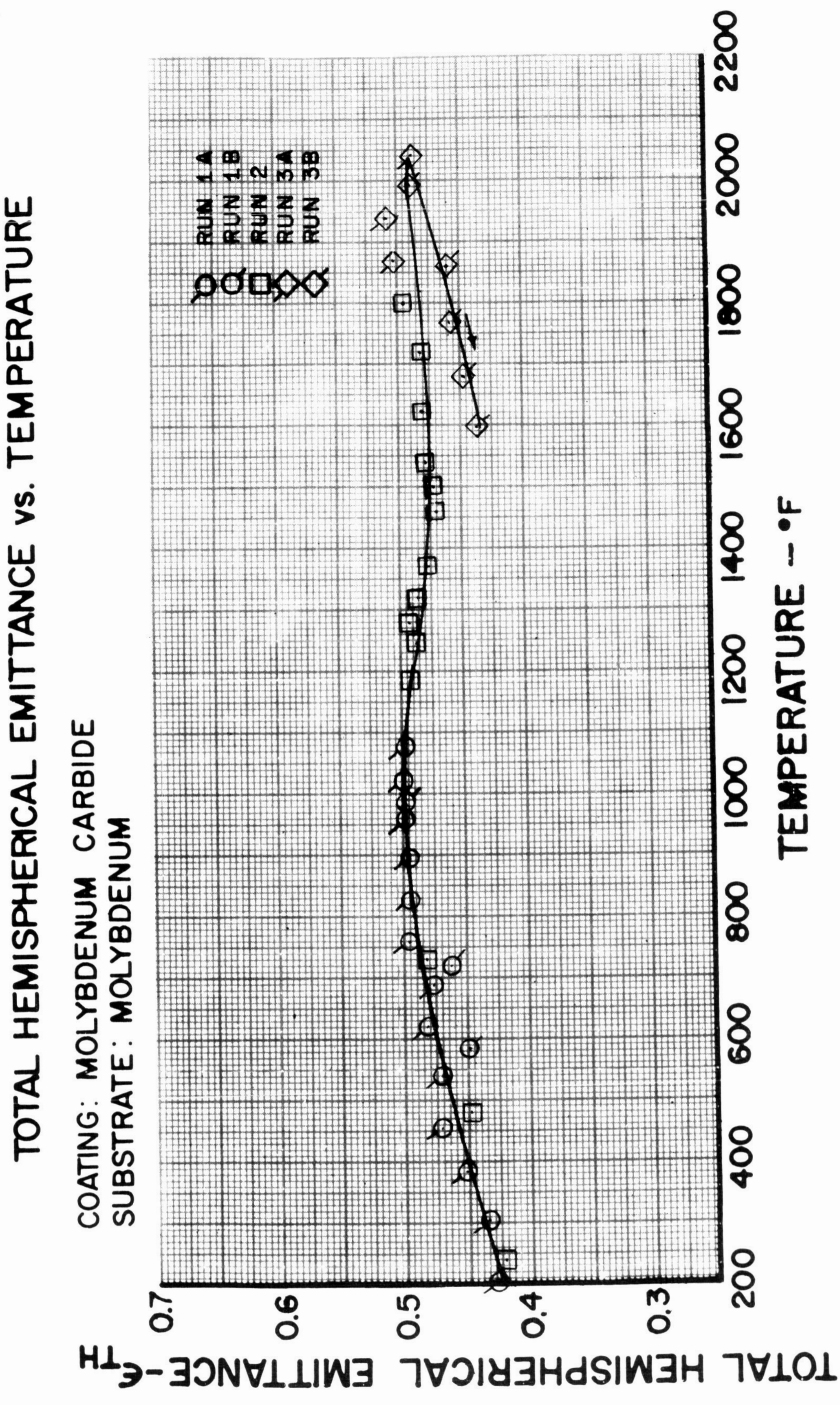

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: MOLYBDENUM CARBIDE
SUBSTRATE: MOLYBDENUM
RUN 1A
RUN 1B
RUN 2
RUN 3A
RUN 3B
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
0.7
0.6
0.5
0.4
0.3
TEMPERATURE — °F
200
400
600
800
1000
1200
1400
1600
1800
2000
2200

Figure 90

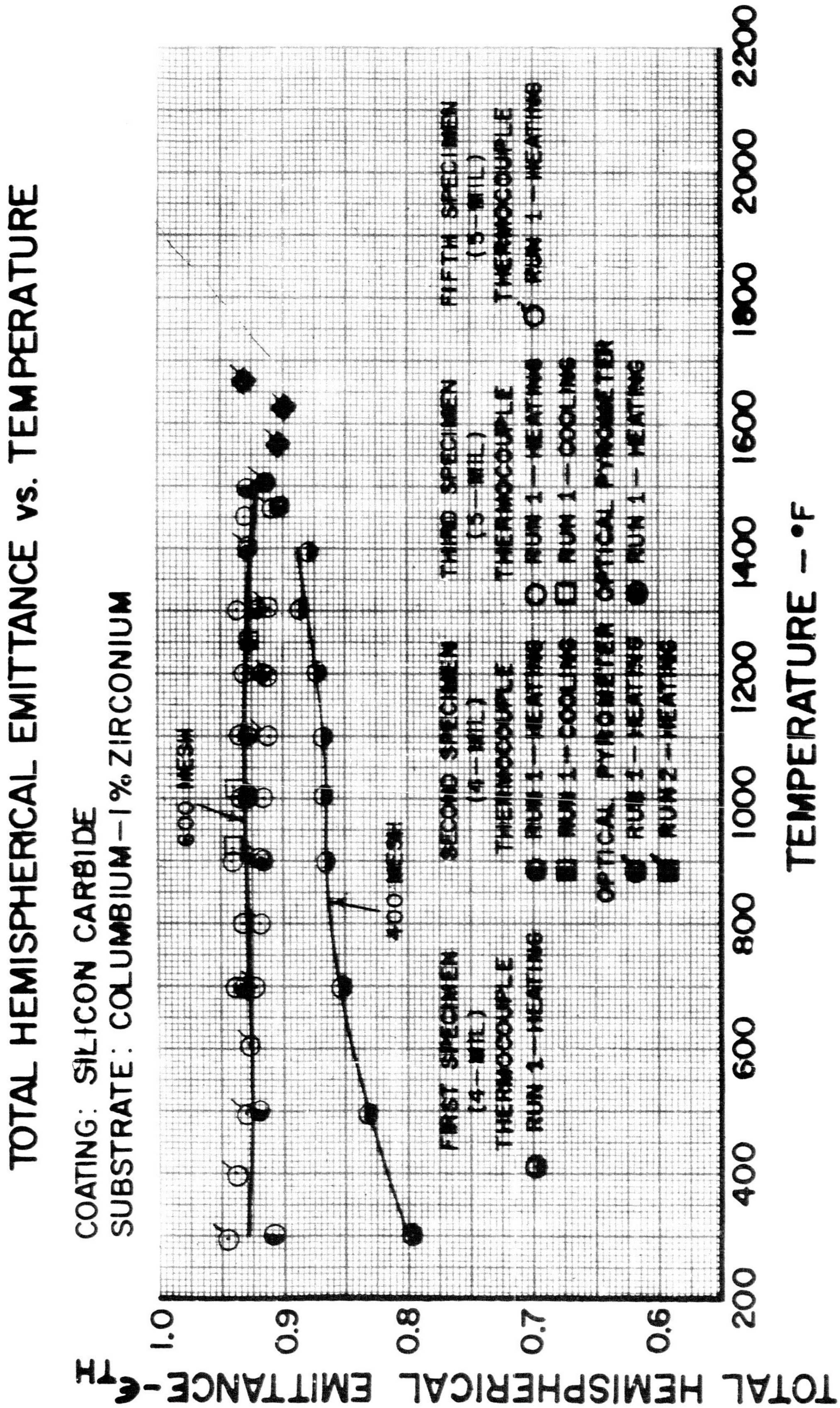

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: SILICON CARBIDE
SUBSTRATE: COLUMBIUM–1% ZIRCONIUM
600 MESH
400 MESH
FIRST SPECIMEN (4–MIL)
THERMOCOUPLE
RUN 1—HEATING
SECOND SPECIMEN (4–MIL)
THERMOCOUPLE
RUN 1—HEATING
RUN 1—COOLING
OPTICAL PYROMETER
RUN 1—HEATING
RUN 2—HEATING
THIRD SPECIMEN (5–MIL)
THERMOCOUPLE
RUN 1—HEATING
RUN 1—COOLING
OPTICAL PYROMETER
RUN 1—HEATING
FIFTH SPECIMEN (5–MIL)
THERMOCOUPLE
RUN 1—HEATING
TOTAL HEMISPHERICAL EMITTANCE–ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 91

SPECTRAL NORMAL EMITTANCE vs. WAVELENGTH

COATING: SILICON CARBIDE
SUBSTRATE: COLUMBIUM - 1% ZIRCONIUM

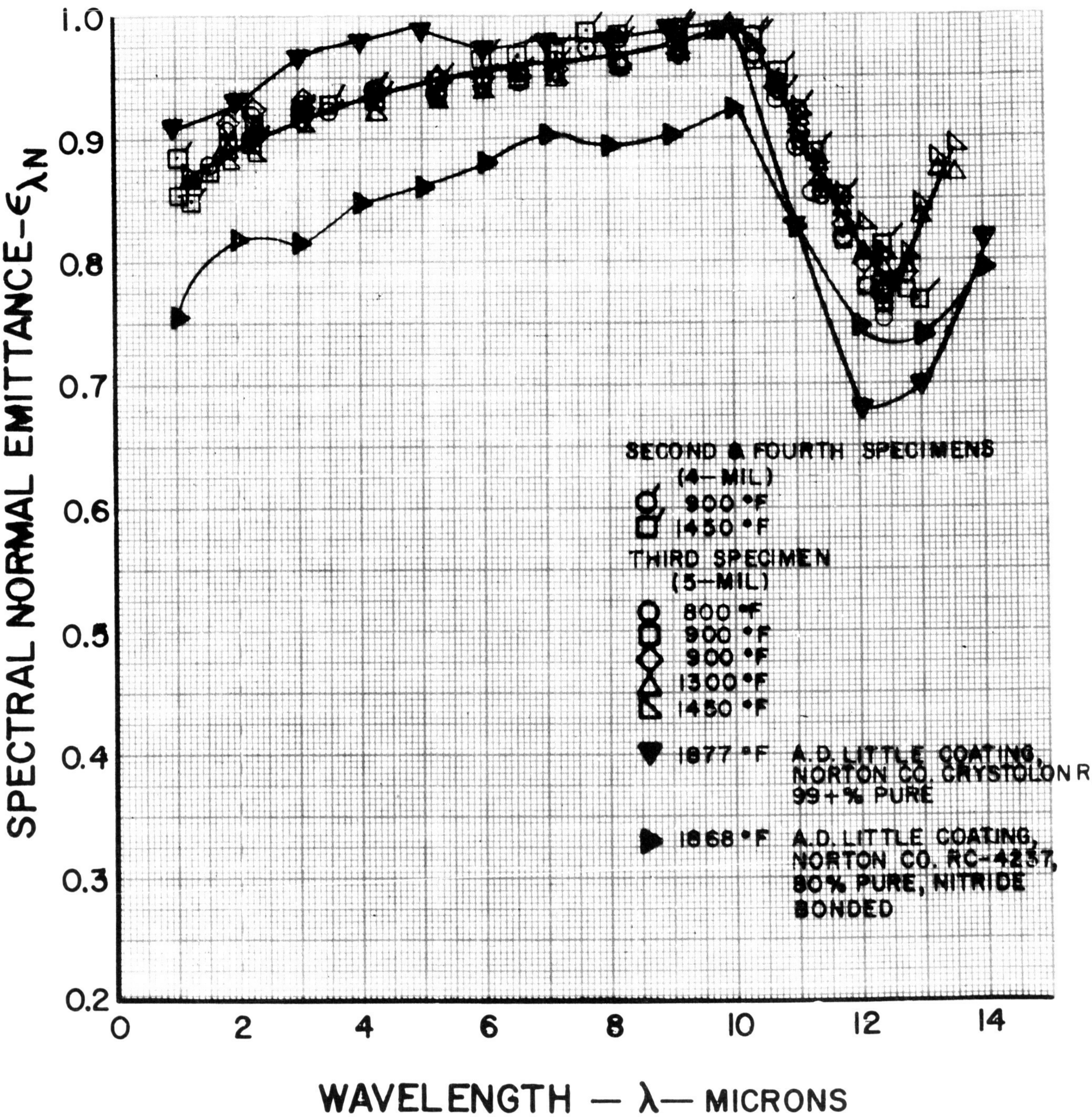


Figure 92

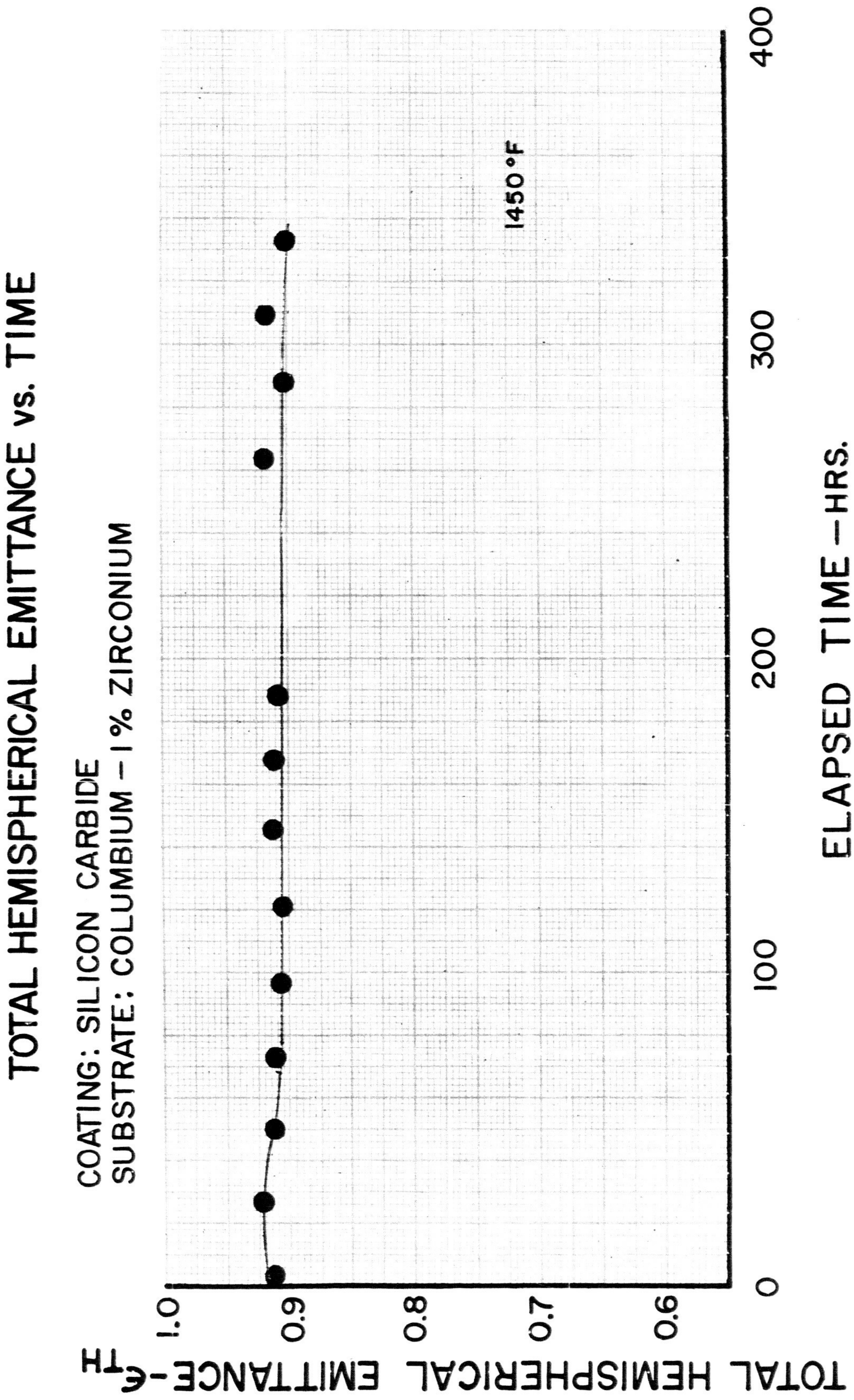

TOTAL HEMISPHERICAL EMITTANCE vs. TIME
COATING: SILICON CARBIDE
SUBSTRATE: COLUMBIUM - 1 % ZIRCONIUM
1450°F
TOTAL HEMISPHERICAL EMITTANCE - ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
ELAPSED TIME — HRS.
0
100
200
300
400

Figure 93

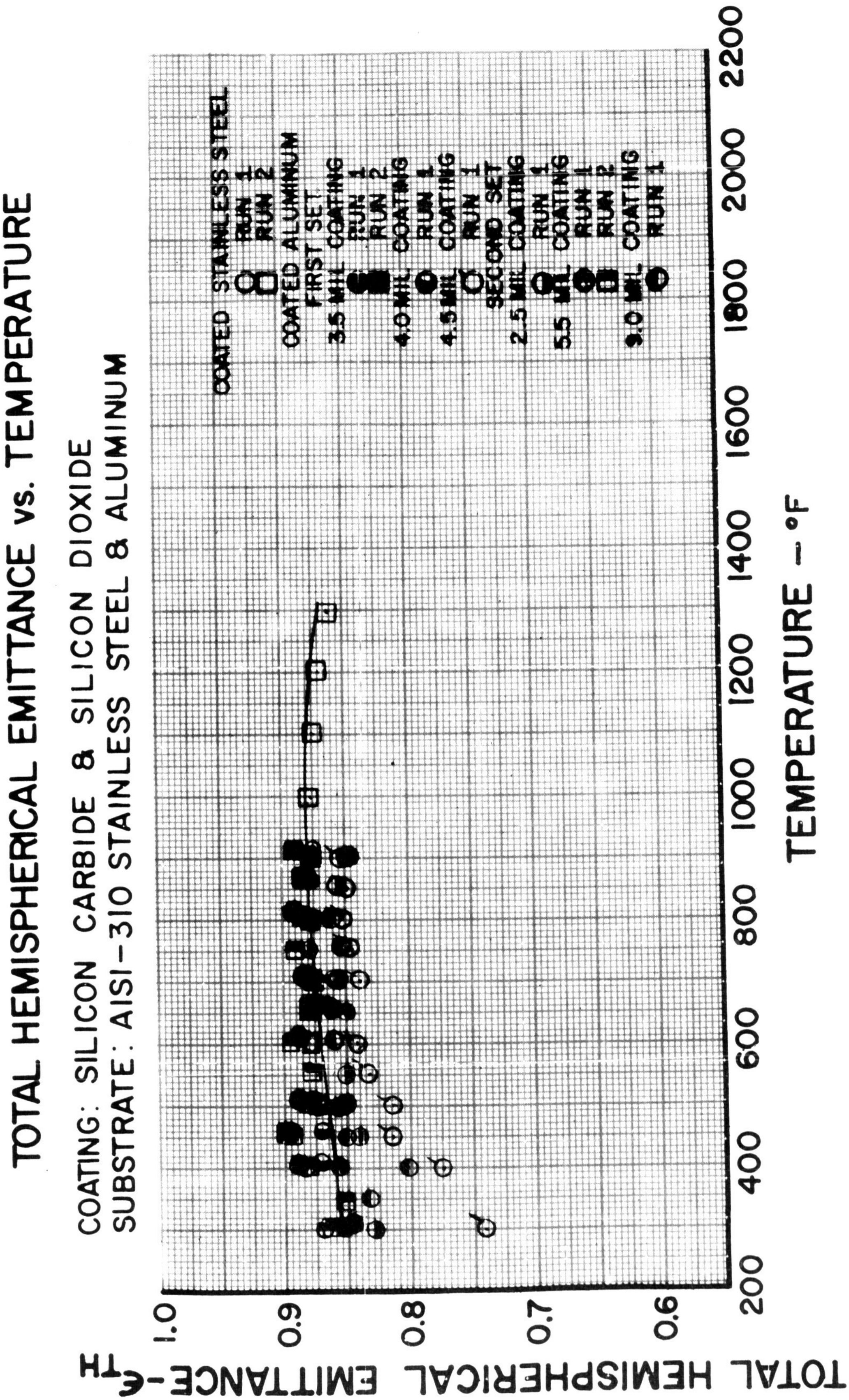
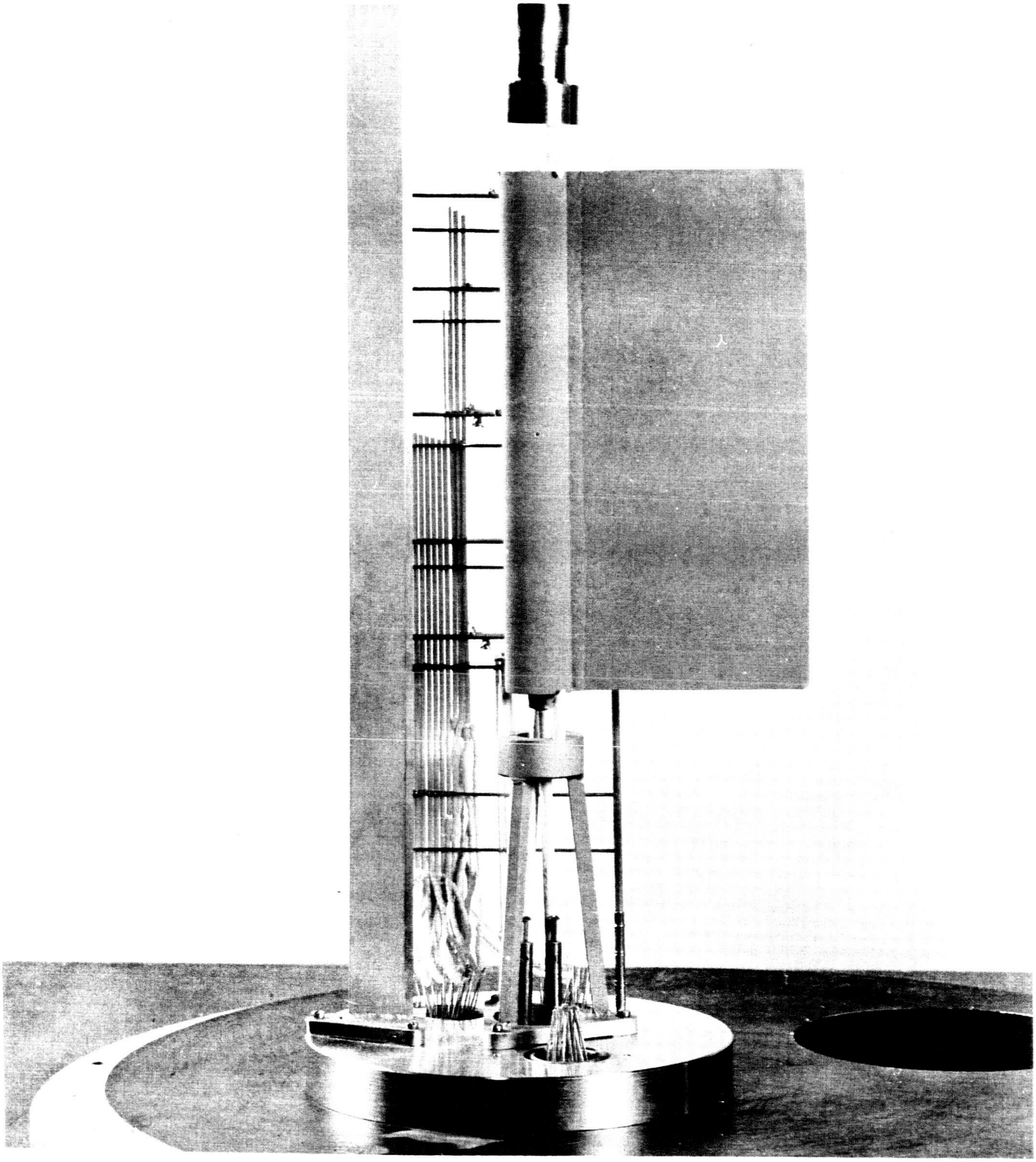
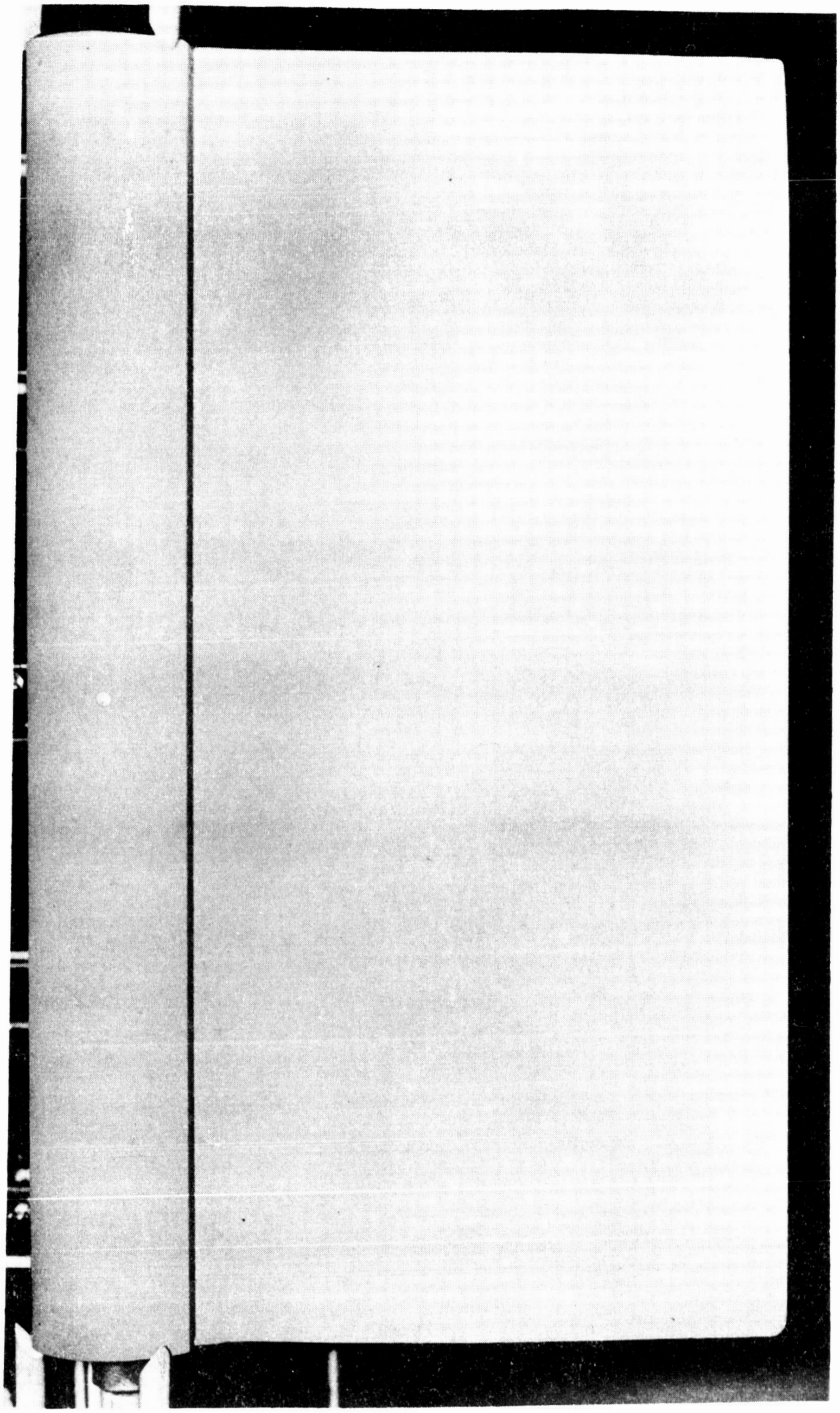

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: SILICON CARBIDE & SILICON DIOXIDE
SUBSTRATE: AISI-310 STAINLESS STEEL & ALUMINUM
COATED STAINLESS STEEL
RUN 1
RUN 2
COATED ALUMINUM
FIRST SET
3.5 MIL COATING
RUN 1
RUN 2
4.0 MIL COATING
RUN 1
4.5 MIL COATING
RUN 1
SECOND SET
2.5 MIL COATING
RUN 1
5.5 MIL COATING
RUN 1
RUN 2
9.0 MIL COATING
RUN 1
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
TEMPERATURE — °F
200
400
600
800
1000
1200
1400
1600
1800
2000
2200

Figure 94



SILICON CARBIDE AND SILICON DIOXIDE COATED SNAP-8 TEST SECTION PRIOR TO TESTING

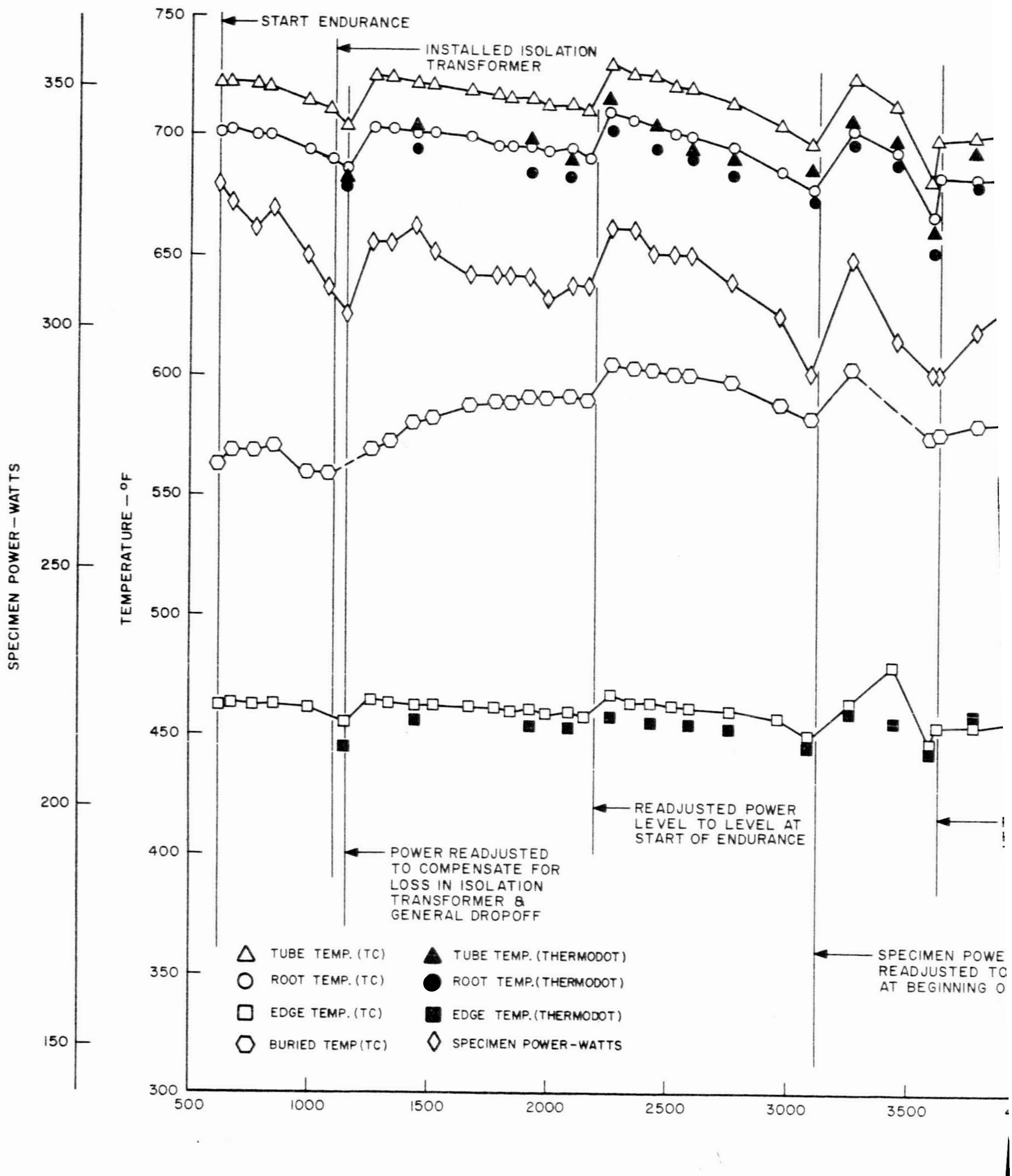
Figure 95



SILICON CARBIDE AND SILICON DIOXIDE COATED SNAP-8
TEST SECTION AFTER 8683 HOURS OF ENDURANCE TESTING

Figure 96

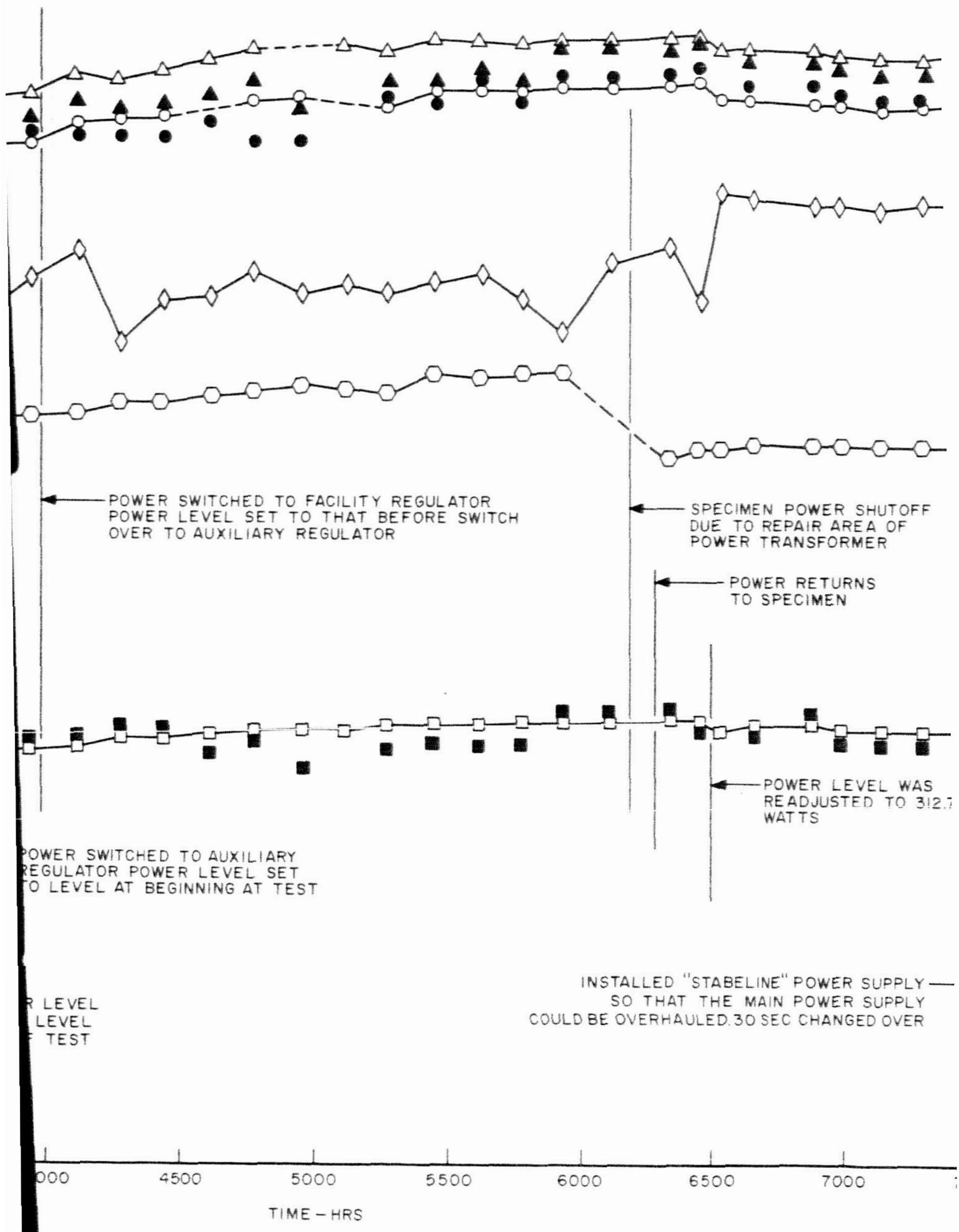
SILICON CARBI[cut off]



97 (1)

LONG TERM ENDURANCE TEST

)E AND SILICA COATING ON SNAP-8 TEST SECTION



97 (2)

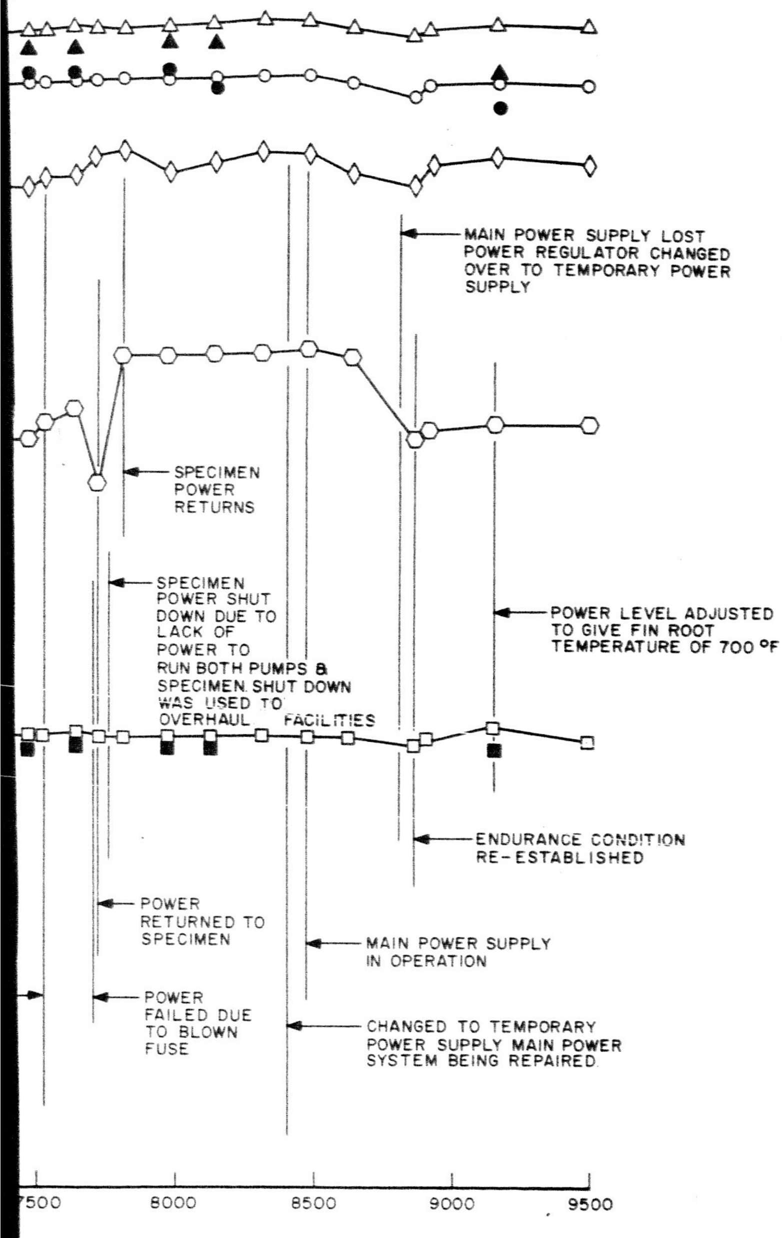

MAIN POWER SUPPLY LOST
POWER REGULATOR CHANGED OVER TO TEMPORARY POWER SUPPLY
SPECIMEN POWER RETURNS
SPECIMEN POWER SHUT DOWN DUE TO LACK OF POWER TO RUN BOTH PUMPS & SPECIMEN. SHUT DOWN WAS USED TO OVERHAUL FACILITIES
POWER LEVEL ADJUSTED TO GIVE FIN ROOT TEMPERATURE OF 700 °F
ENDURANCE CONDITION RE-ESTABLISHED
POWER RETURNED TO SPECIMEN
MAIN POWER SUPPLY IN OPERATION
POWER FAILED DUE TO BLOWN FUSE
CHANGED TO TEMPORARY POWER SUPPLY MAIN POWER SYSTEM BEING REPAIRED
7500
8000
8500
9000
9500

Figure 97

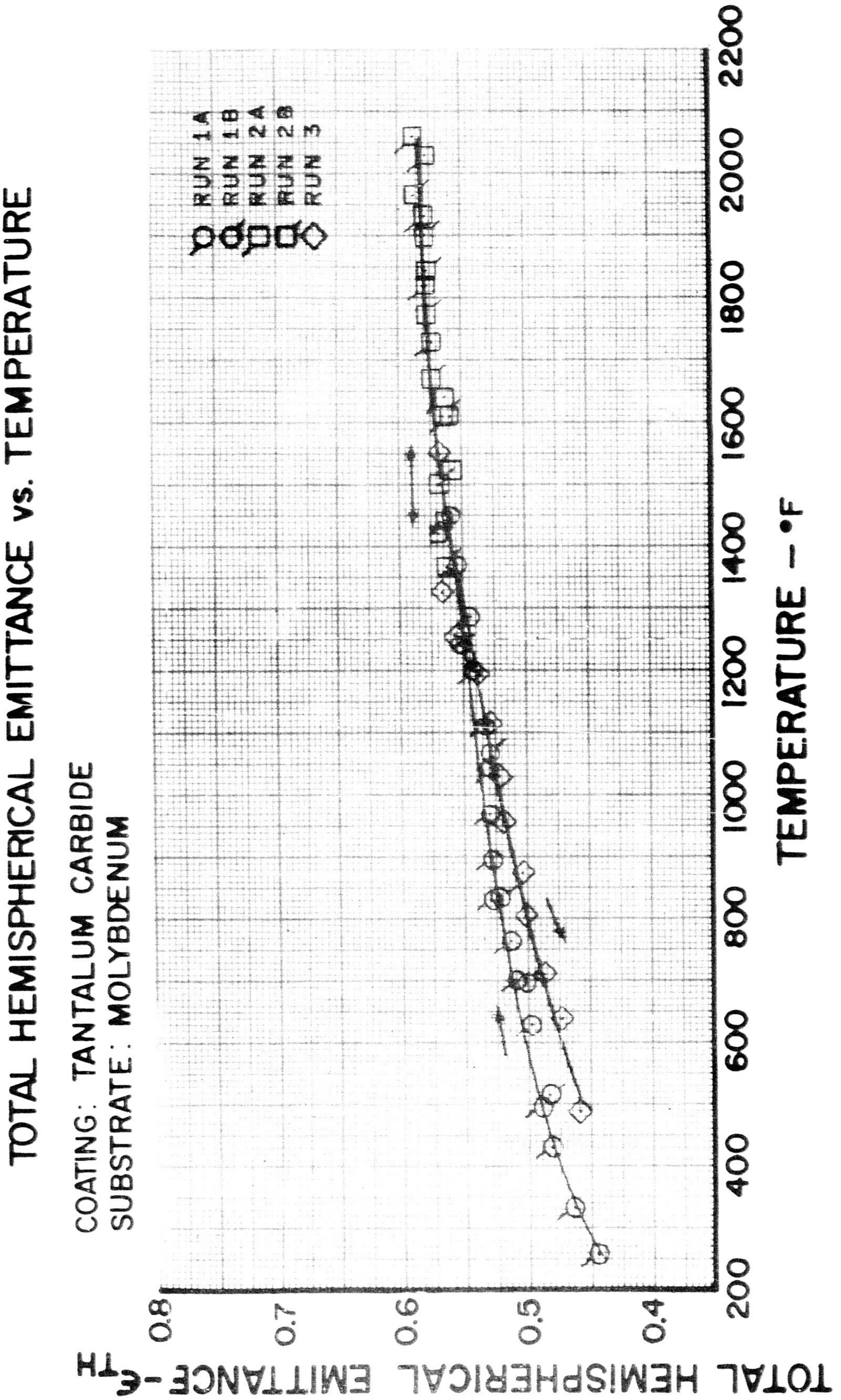

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: TANTALUM CARBIDE
SUBSTRATE: MOLYBDENUM
RUN 1A
RUN 1B
RUN 2A
RUN 2B
RUN 3
TEMPERATURE — °F
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
0.4
0.5
0.6
0.7
0.8

Figure 98

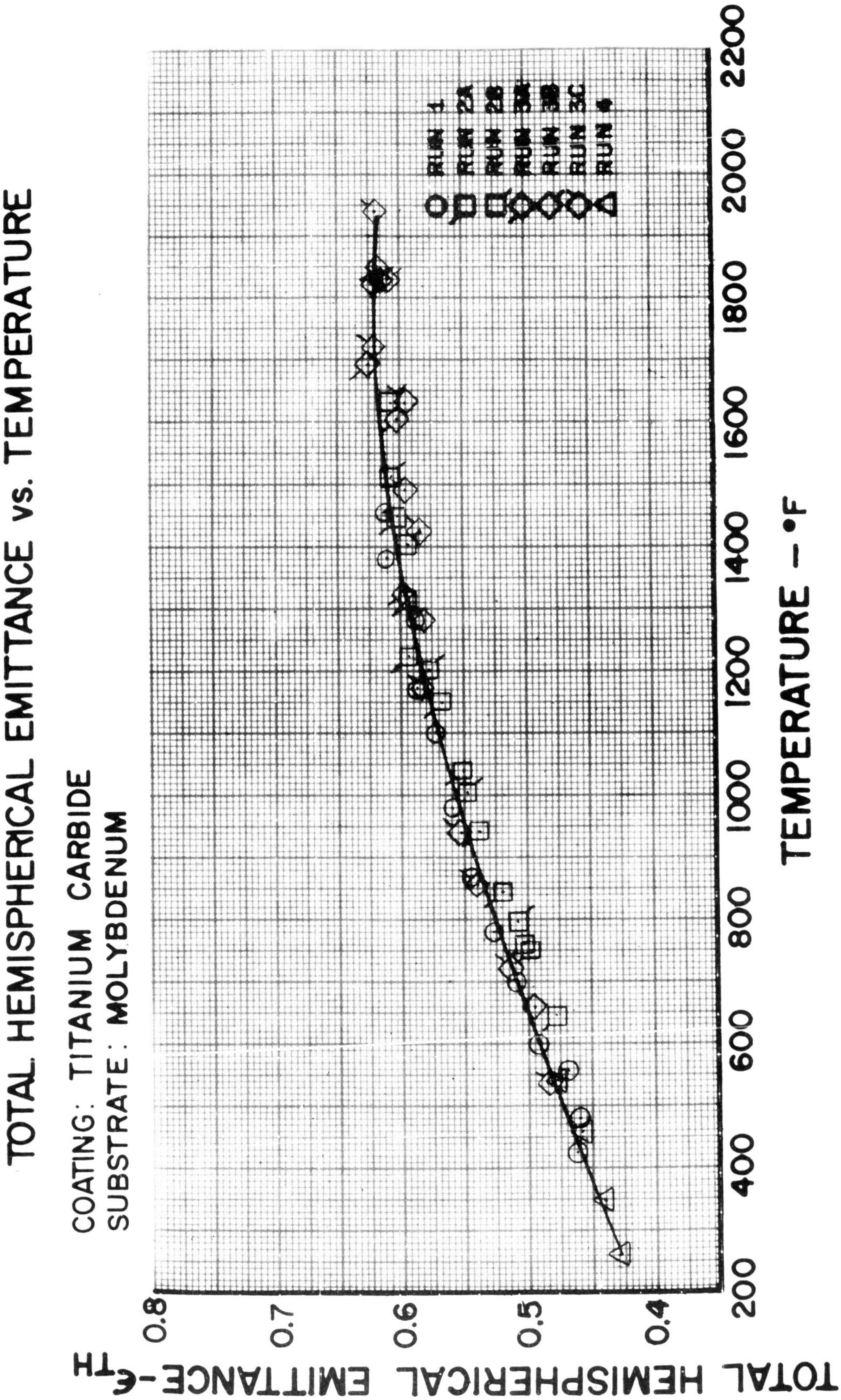

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: TITANIUM CARBIDE
SUBSTRATE: MOLYBDENUM
RUN 1
RUN 2A
RUN 2B
RUN 3A
RUN 3B
RUN 3C
RUN 4
TEMPERATURE — °F
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TOTAL HEMISPHERICAL EMITTANCE-ε TH
0.8
0.7
0.6
0.5
0.4

Figure 99

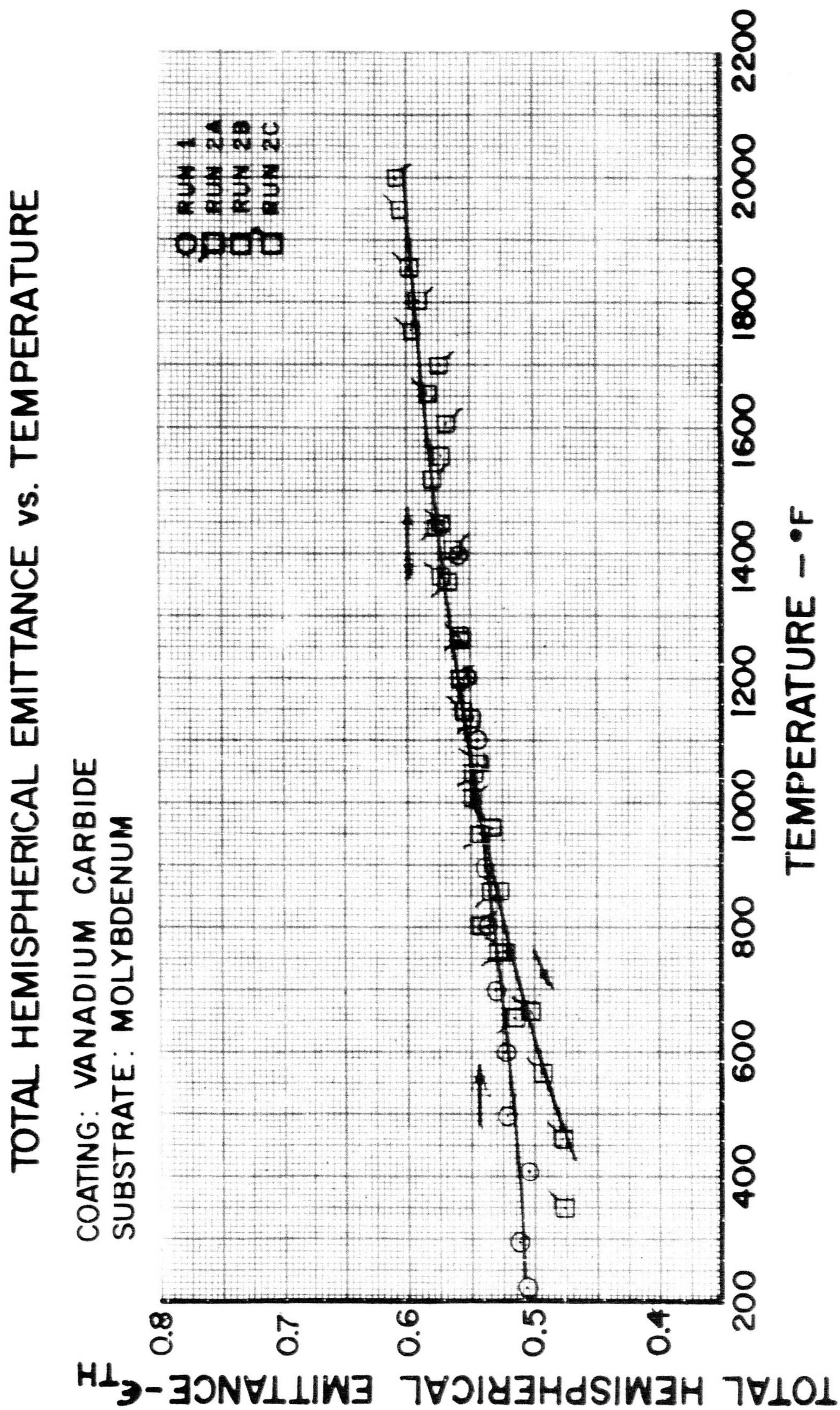

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: VANADIUM CARBIDE
SUBSTRATE: MOLYBDENUM
RUN 1
RUN 2A
RUN 2B
RUN 2C
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
0.8
0.7
0.6
0.5
0.4
TEMPERATURE — °F
200
400
600
800
1000
1200
1400
1600
1800
2000
2200

Figure 100

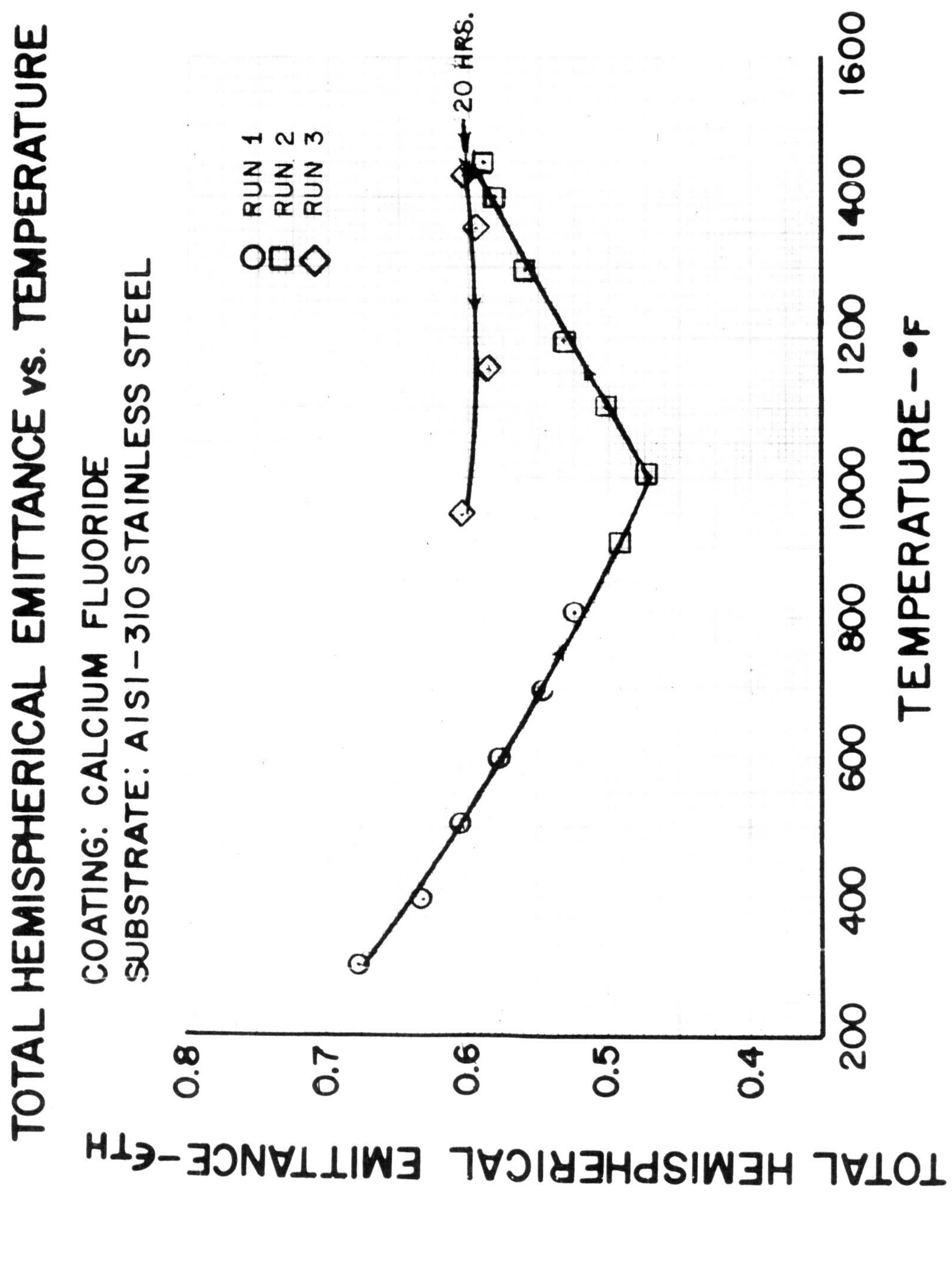

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: CALCIUM FLUORIDE
SUBSTRATE: AISI-310 STAINLESS STEEL
RUN 1
RUN 2
RUN 3
20 HRS.
0.8
0.7
0.6
0.5
0.4
200
400
600
800
1000
1200
1400
1600
TEMPERATURE — °F
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}

Figure 101

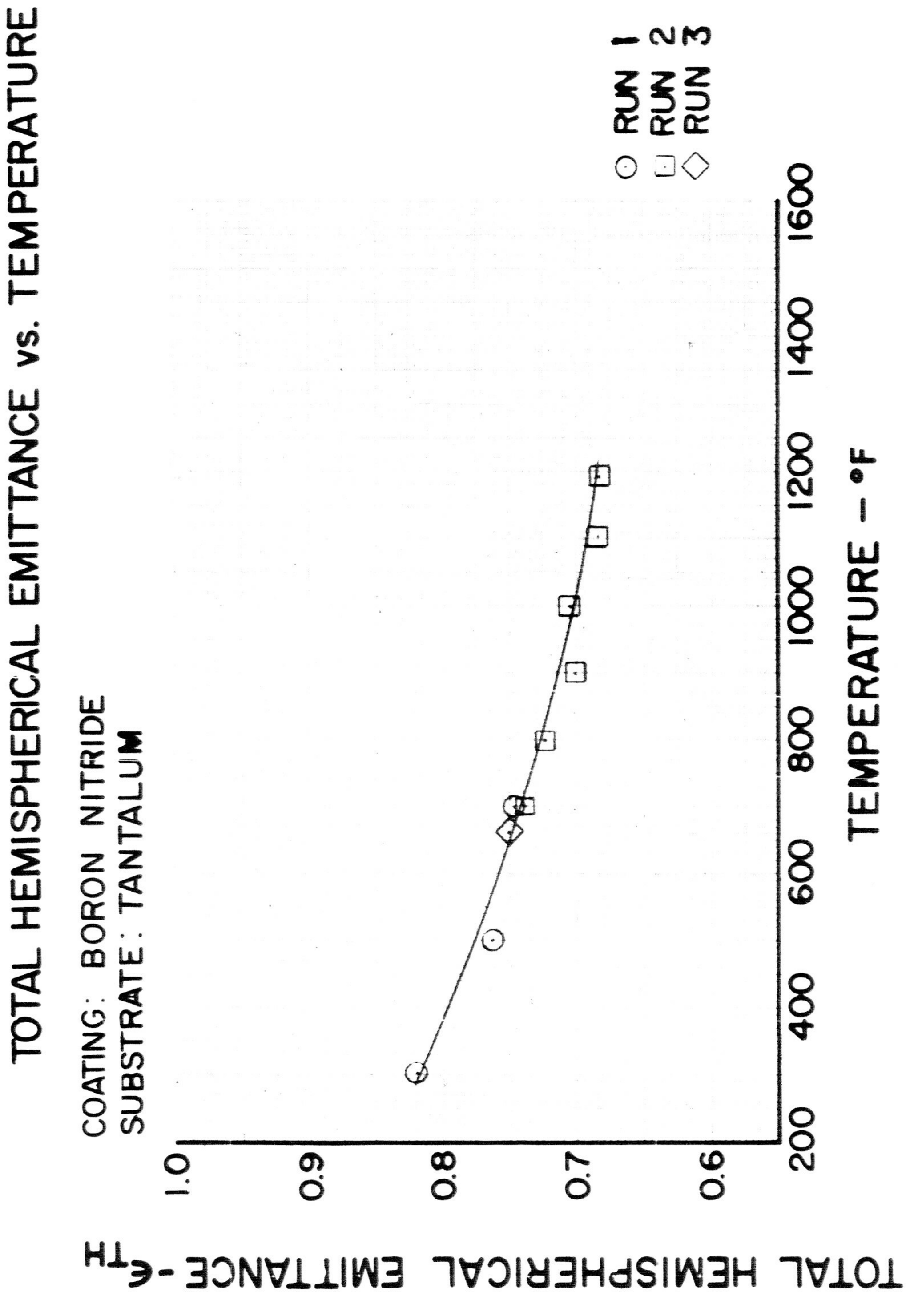

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: BORON NITRIDE
SUBSTRATE: TANTALUM
RUN 1
RUN 2
RUN 3
TOTAL HEMISPHERICAL EMITTANCE - ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
TEMPERATURE — °F

Figure 102

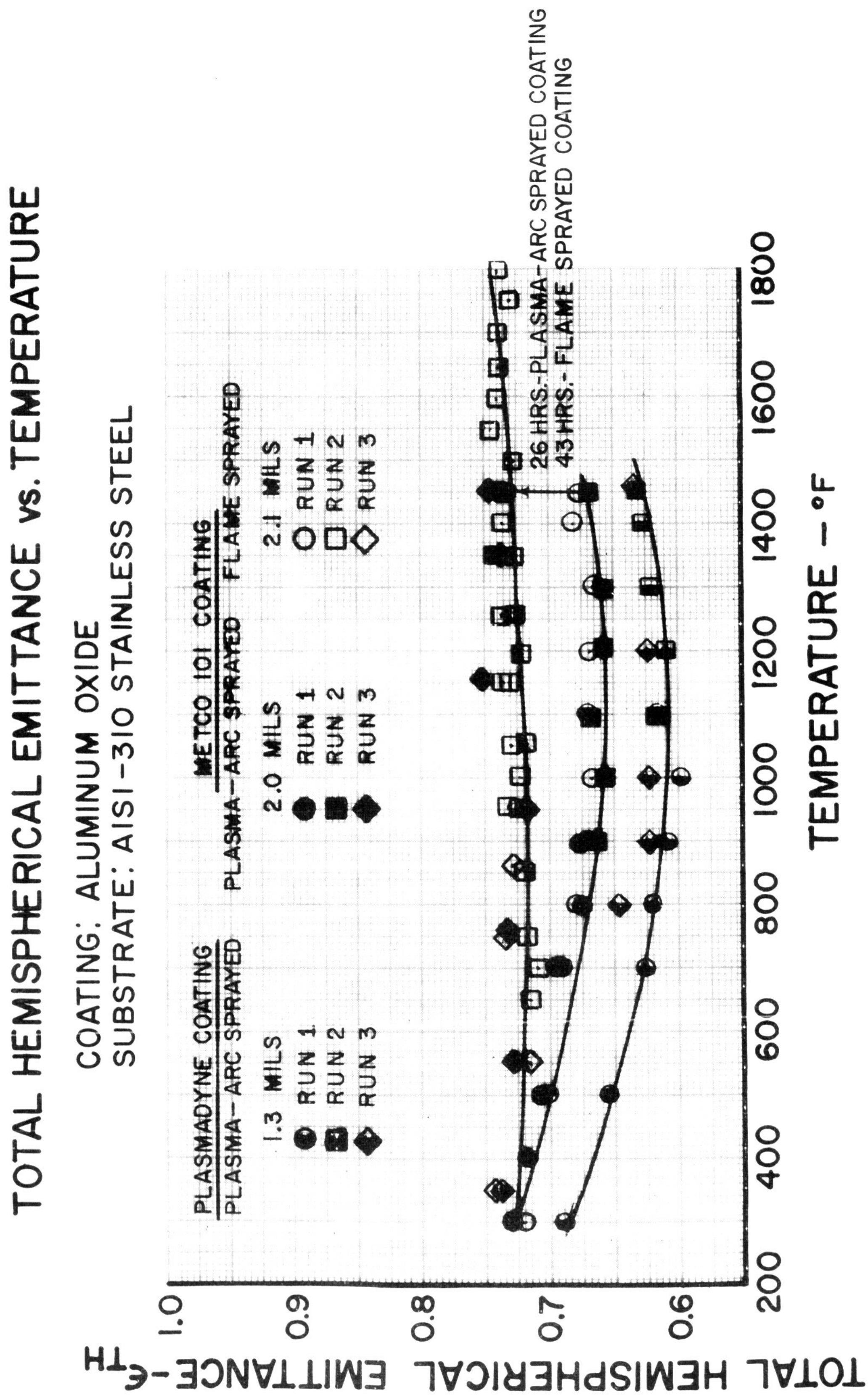

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: ALUMINUM OXIDE
SUBSTRATE: AISI-310 STAINLESS STEEL
PLASMADYNE COATING
PLASMA-ARC SPRAYED
1.3 MILS
RUN 1
RUN 2
RUN 3
METCO 101 COATING
PLASMA-ARC SPRAYED
2.0 MILS
RUN 1
RUN 2
RUN 3
FLAME SPRAYED
2.1 MILS
RUN 1
RUN 2
RUN 3
26 HRS.-PLASMA-ARC SPRAYED COATING
43 HRS.- FLAME SPRAYED COATING
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
TEMPERATURE — °F

Figure 103

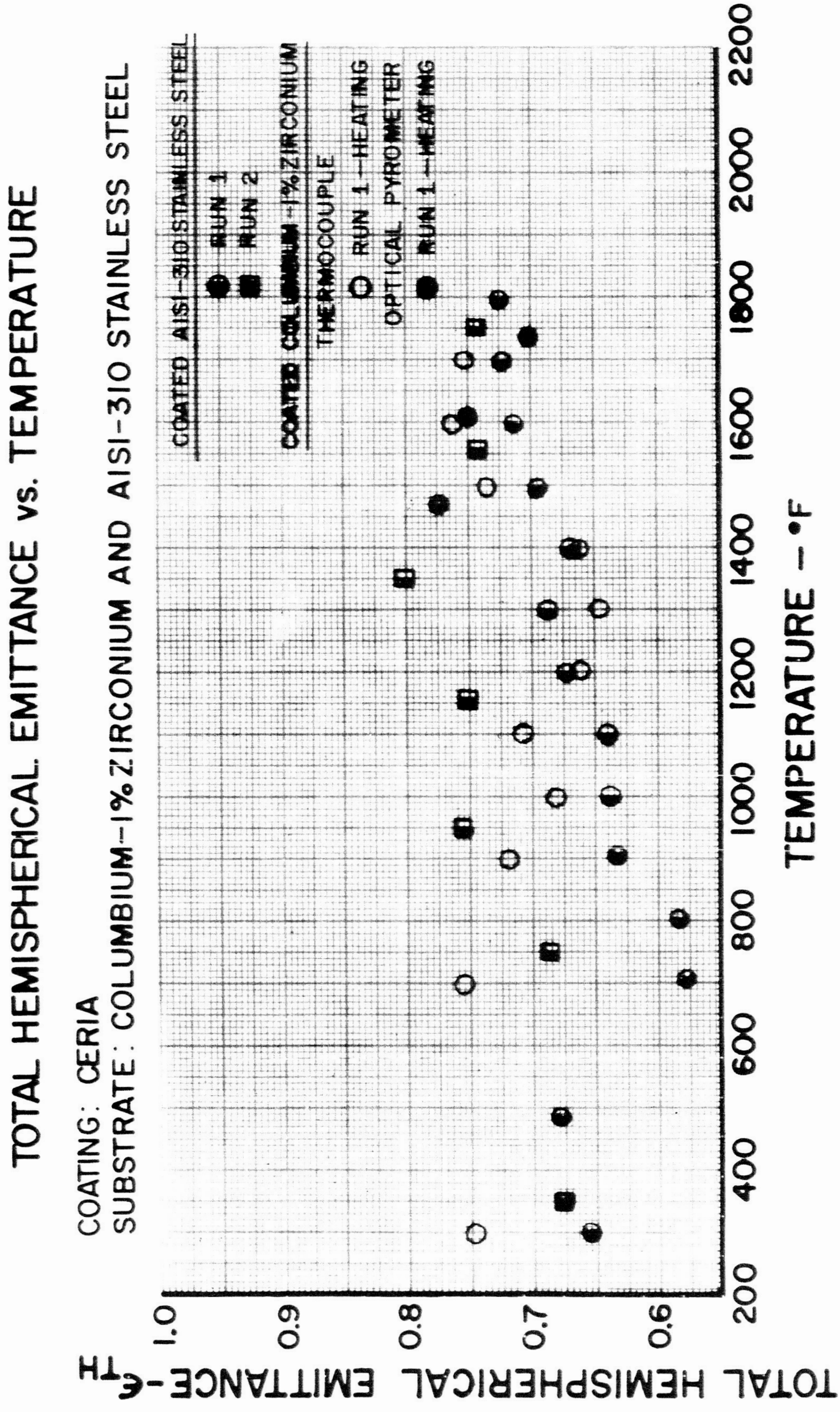

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: CERIA
SUBSTRATE: COLUMBIUM–1% ZIRCONIUM AND AISI-310 STAINLESS STEEL
COATED AISI-310 STAINLESS STEEL
RUN 1
RUN 2
COATED COLUMBIUM -1% ZIRCONIUM
THERMOCOUPLE
RUN 1—HEATING
OPTICAL PYROMETER
RUN 1—HEATING
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 104

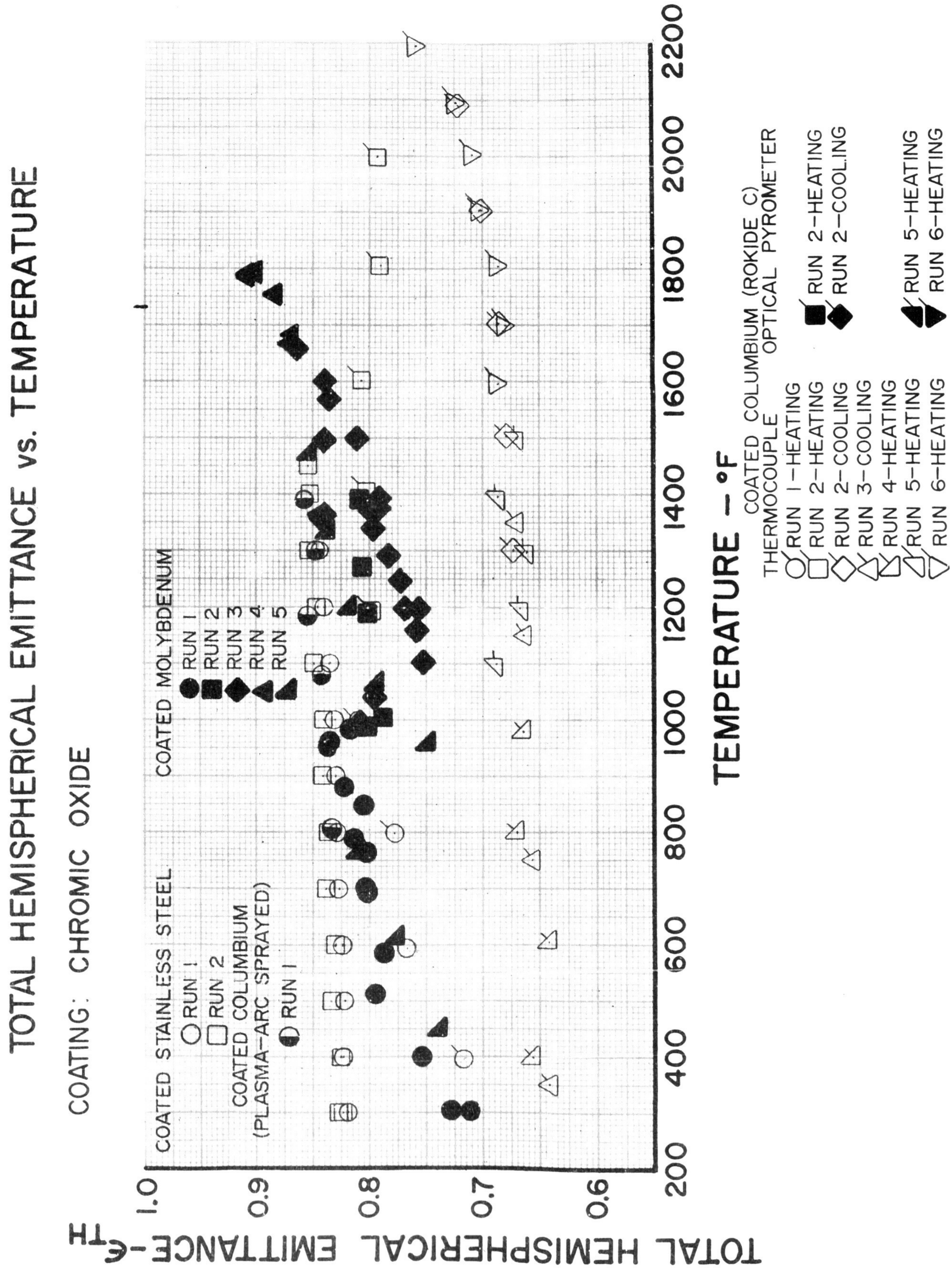
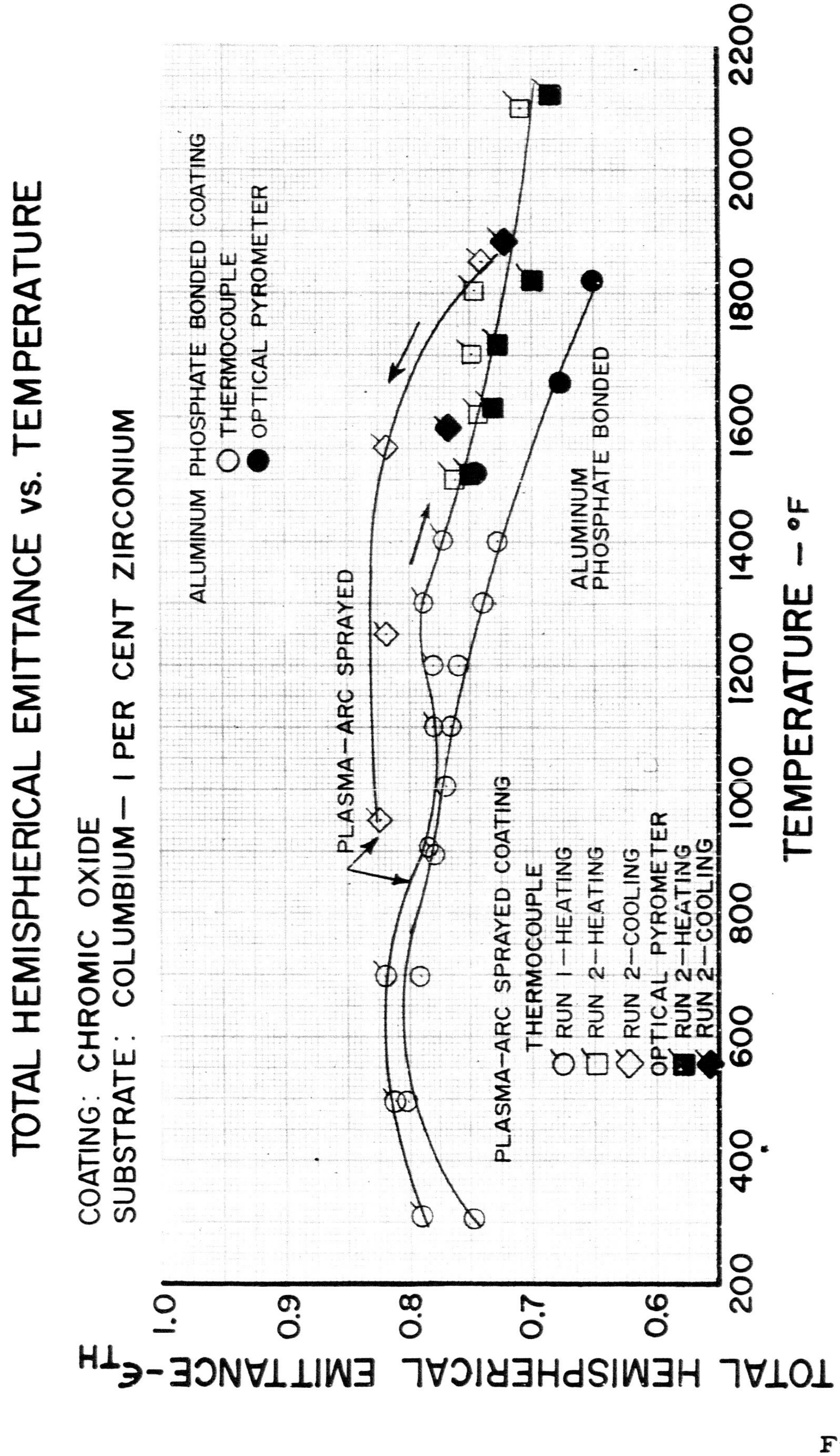

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: CHROMIC OXIDE
COATED STAINLESS STEEL
RUN 1
RUN 2
COATED COLUMBIUM
(PLASMA-ARC SPRAYED)
RUN 1
COATED MOLYBDENUM
RUN 1
RUN 2
RUN 3
RUN 4
RUN 5
COATED COLUMBIUM (ROKIDE C)
THERMOCOUPLE
RUN 1-HEATING
RUN 2-HEATING
RUN 2-COOLING
RUN 3-COOLING
RUN 4-HEATING
RUN 5-HEATING
RUN 6-HEATING
OPTICAL PYROMETER
RUN 2-HEATING
RUN 2-COOLING
RUN 5-HEATING
RUN 6-HEATING
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
TEMPERATURE — °F
200
400
600
800
1000
1200
1400
1600
1800
2000
2200

Figure 105 a



TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: CHROMIC OXIDE
SUBSTRATE: COLUMBIUM— I PER CENT ZIRCONIUM
ALUMINUM PHOSPHATE BONDED COATING
THERMOCOUPLE
OPTICAL PYROMETER
PLASMA-ARC SPRAYED
ALUMINUM PHOSPHATE BONDED
PLASMA-ARC SPRAYED COATING
THERMOCOUPLE
RUN I—HEATING
RUN 2—HEATING
RUN 2—COOLING
OPTICAL PYROMETER
RUN 2—HEATING
RUN 2—COOLING
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 105 b

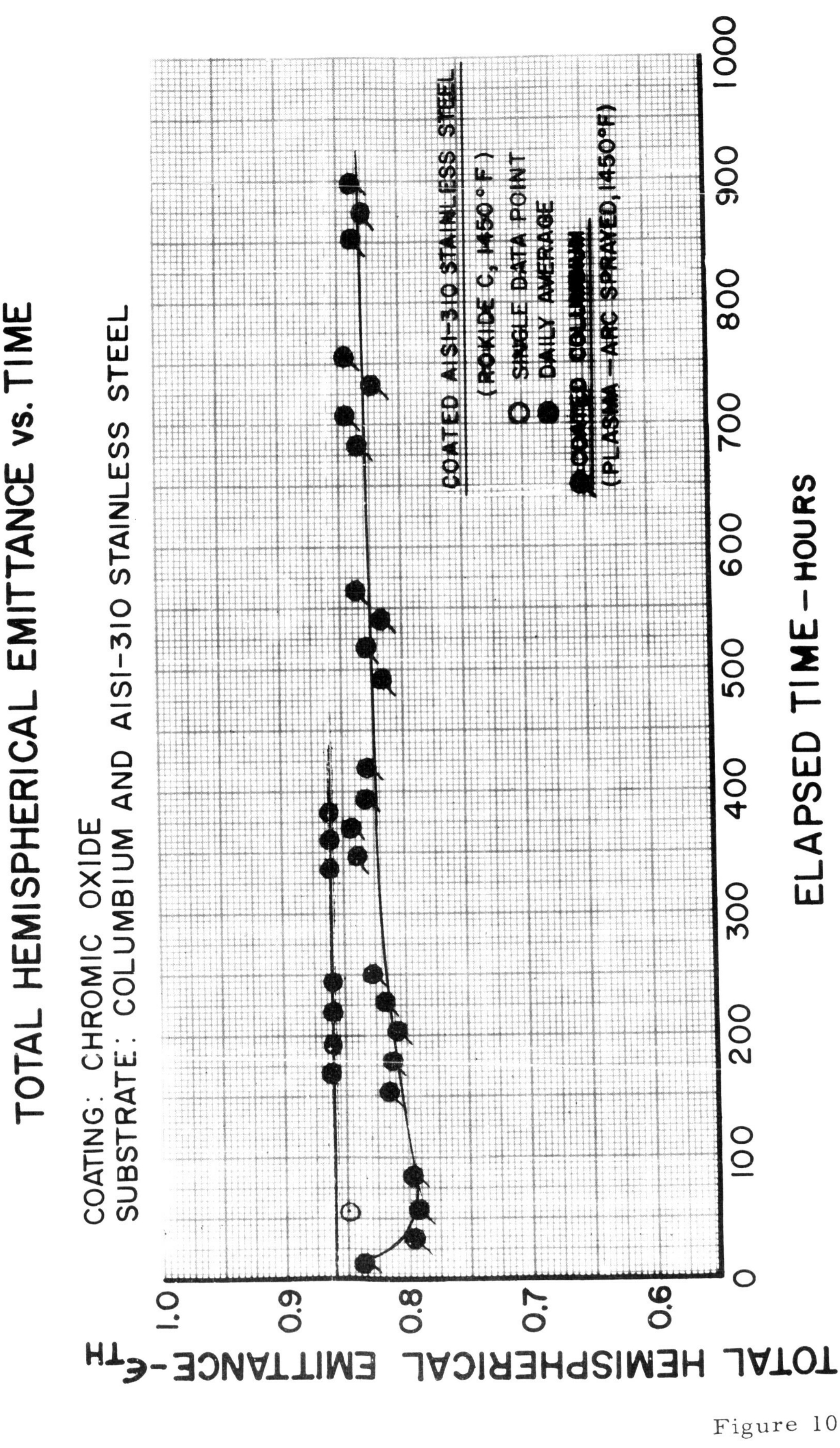

TOTAL HEMISPHERICAL EMITTANCE vs. TIME
COATING: CHROMIC OXIDE
SUBSTRATE: COLUMBIUM AND AISI-310 STAINLESS STEEL
COATED AISI-310 STAINLESS STEEL
(ROKIDE C, 1450°F)
SINGLE DATA POINT
DAILY AVERAGE
COATED COLUMBIUM
(PLASMA - ARC SPRAYED, 1450°F)
ELAPSED TIME - HOURS
TOTAL HEMISPHERICAL EMITTANCE - ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
0
100
200
300
400
500
600
700
800
900
1000

Figure 106

SPECTRAL NORMAL EMITTANCE VS WAVELENGTH

COATING: CHROMIC OXIDE (ROKIDE)
SUBSTRATE: COLUMBIUM

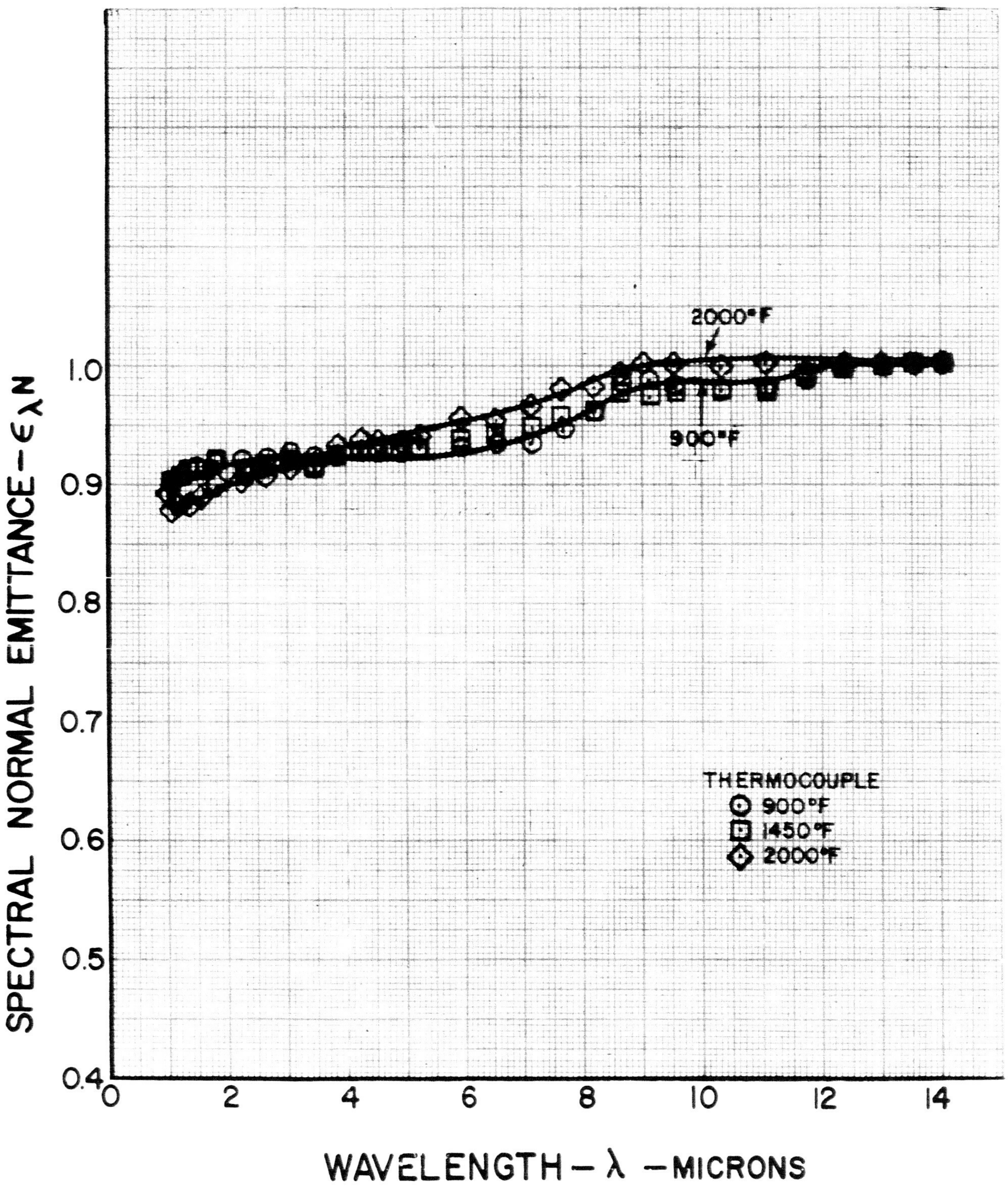


Figure 107

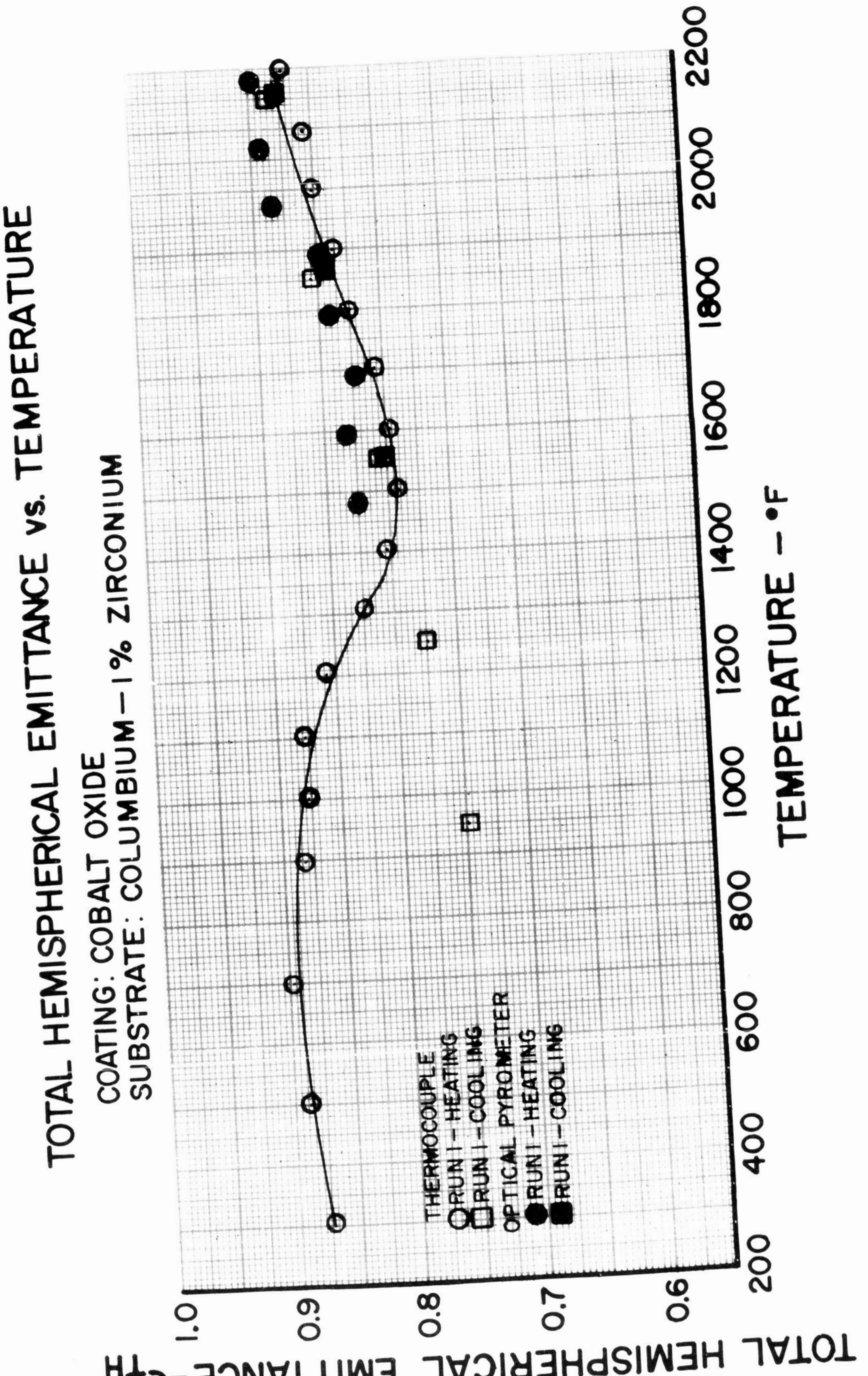

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: COBALT OXIDE
SUBSTRATE: COLUMBIUM—1% ZIRCONIUM
THERMOCOUPLE
RUN I - HEATING
RUN I - COOLING
OPTICAL PYROMETER
RUN I - HEATING
RUN I - COOLING
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
TEMPERATURE — °F
200
400
600
800
1000
1200
1400
1600
1800
2000
2200

Figure 108

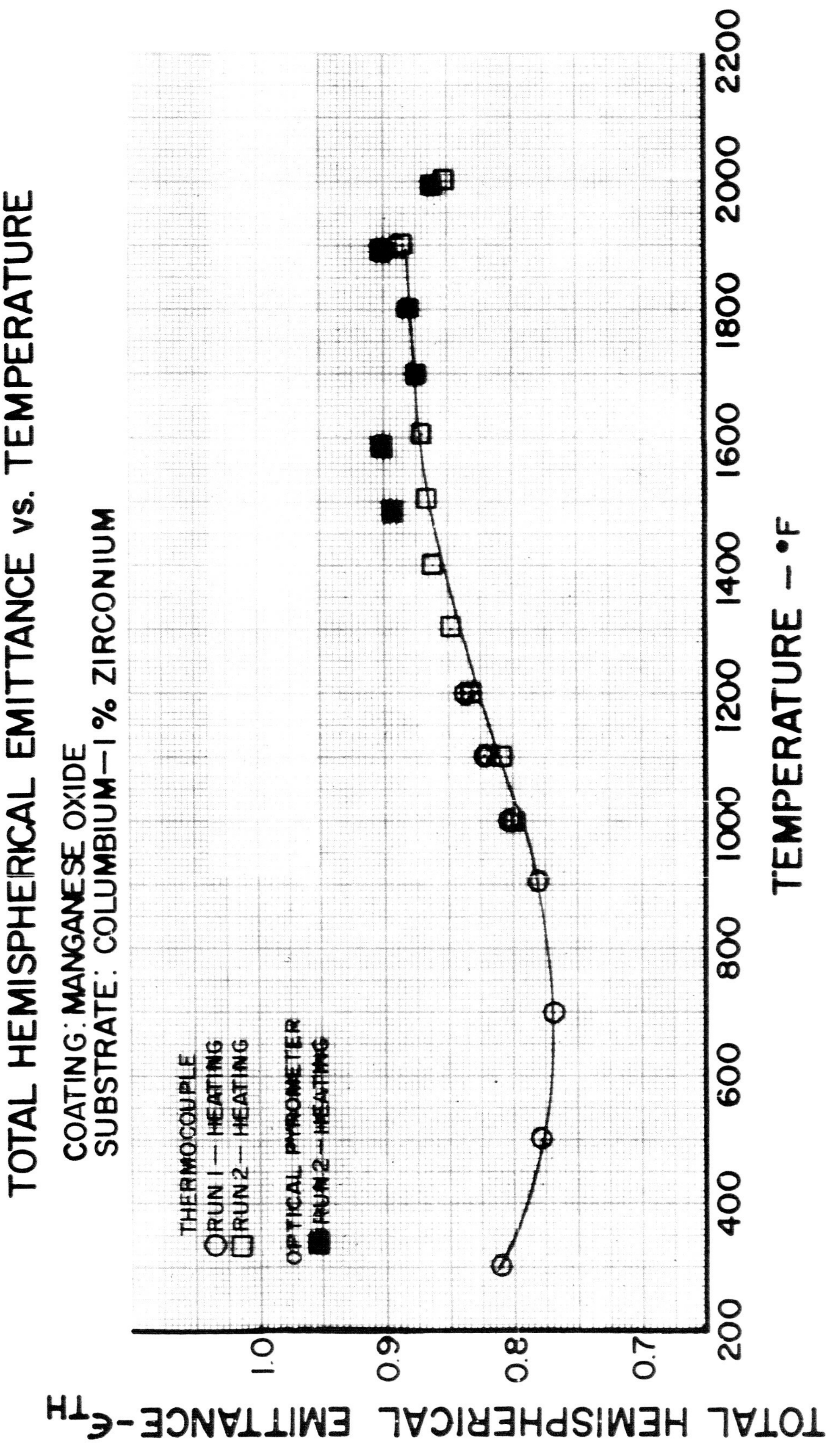

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: MANGANESE OXIDE
SUBSTRATE: COLUMBIUM—1% ZIRCONIUM
THERMOCOUPLE
RUN 1 — HEATING
RUN 2 — HEATING
OPTICAL PYROMETER
RUN 2 — HEATING
TEMPERATURE — °F
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
1.0
0.9
0.8
0.7
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}

Figure 109

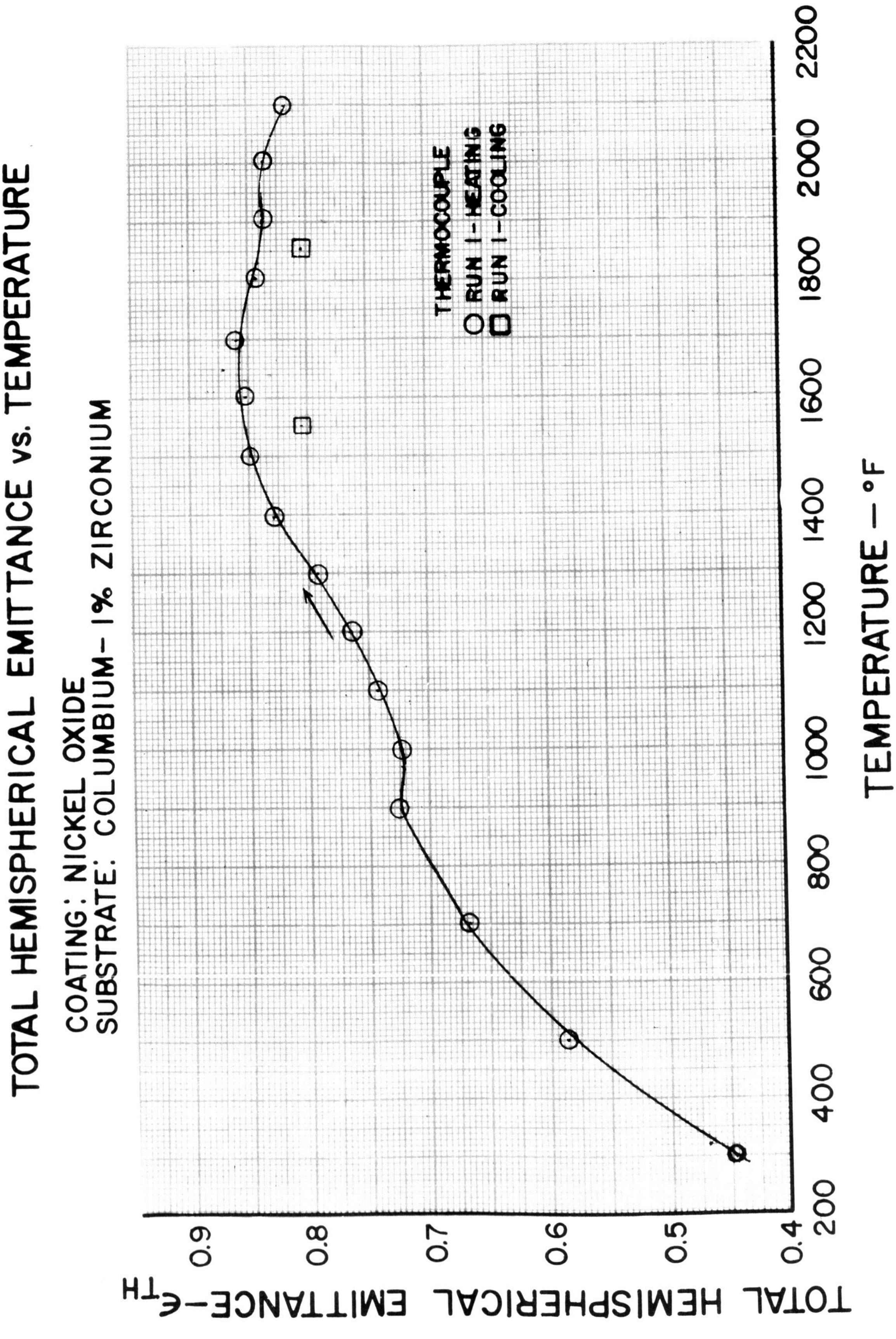

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: NICKEL OXIDE
SUBSTRATE: COLUMBIUM- 1% ZIRCONIUM
THERMOCOUPLE
RUN I-HEATING
RUN I-COOLING
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
0.4
0.5
0.6
0.7
0.8
0.9
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 110

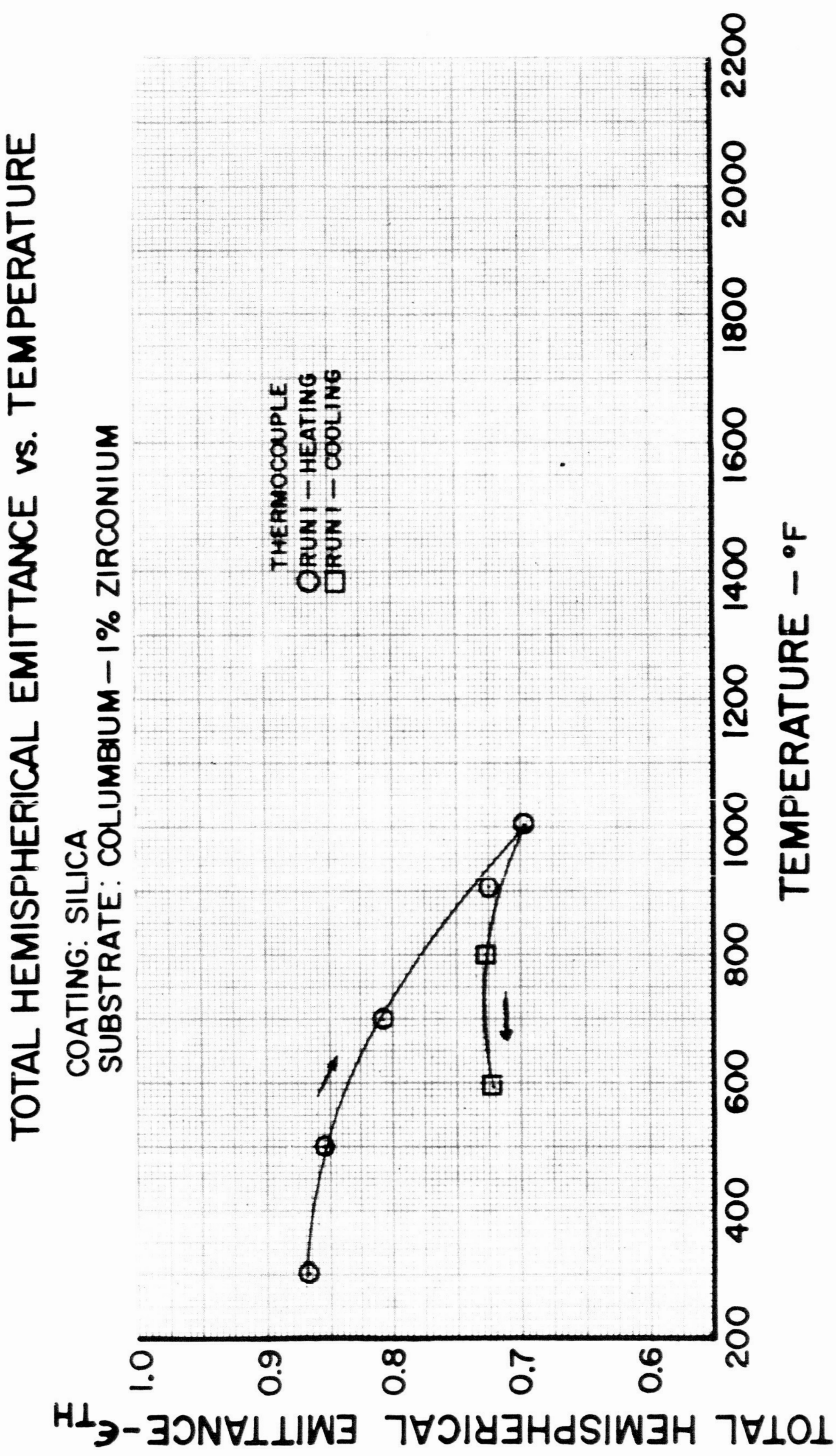

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: SILICA
SUBSTRATE: COLUMBIUM—1% ZIRCONIUM
THERMOCOUPLE
RUN I — HEATING
RUN I — COOLING
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
TEMPERATURE — °F
200
400
600
800
1000
1200
1400
1600
1800
2000
2200

Figure 111

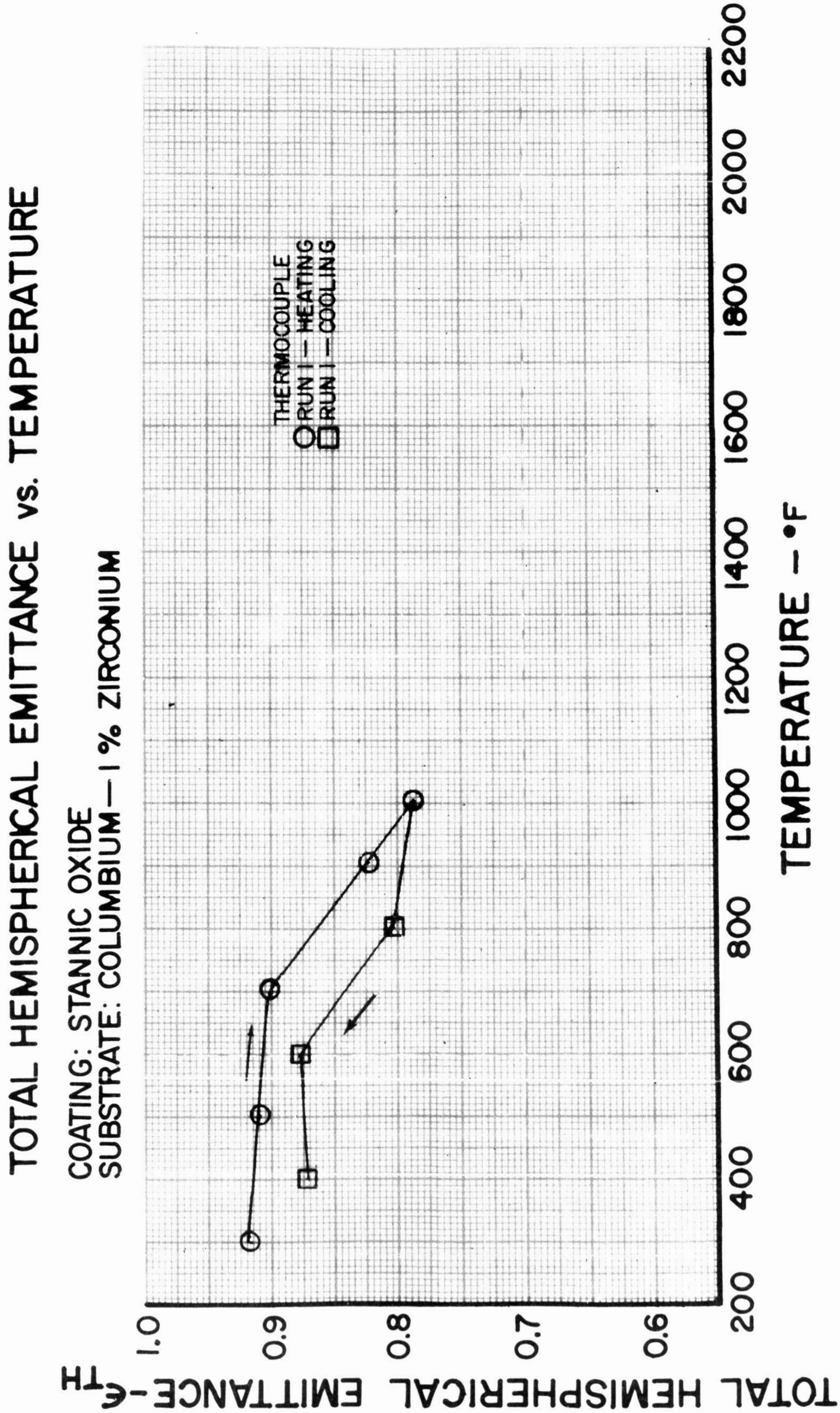

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: STANNIC OXIDE
SUBSTRATE: COLUMBIUM—1% ZIRCONIUM
THERMOCOUPLE
RUN I — HEATING
RUN I — COOLING
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F
1.0
0.9
0.8
0.7
0.6
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}

Figure 112

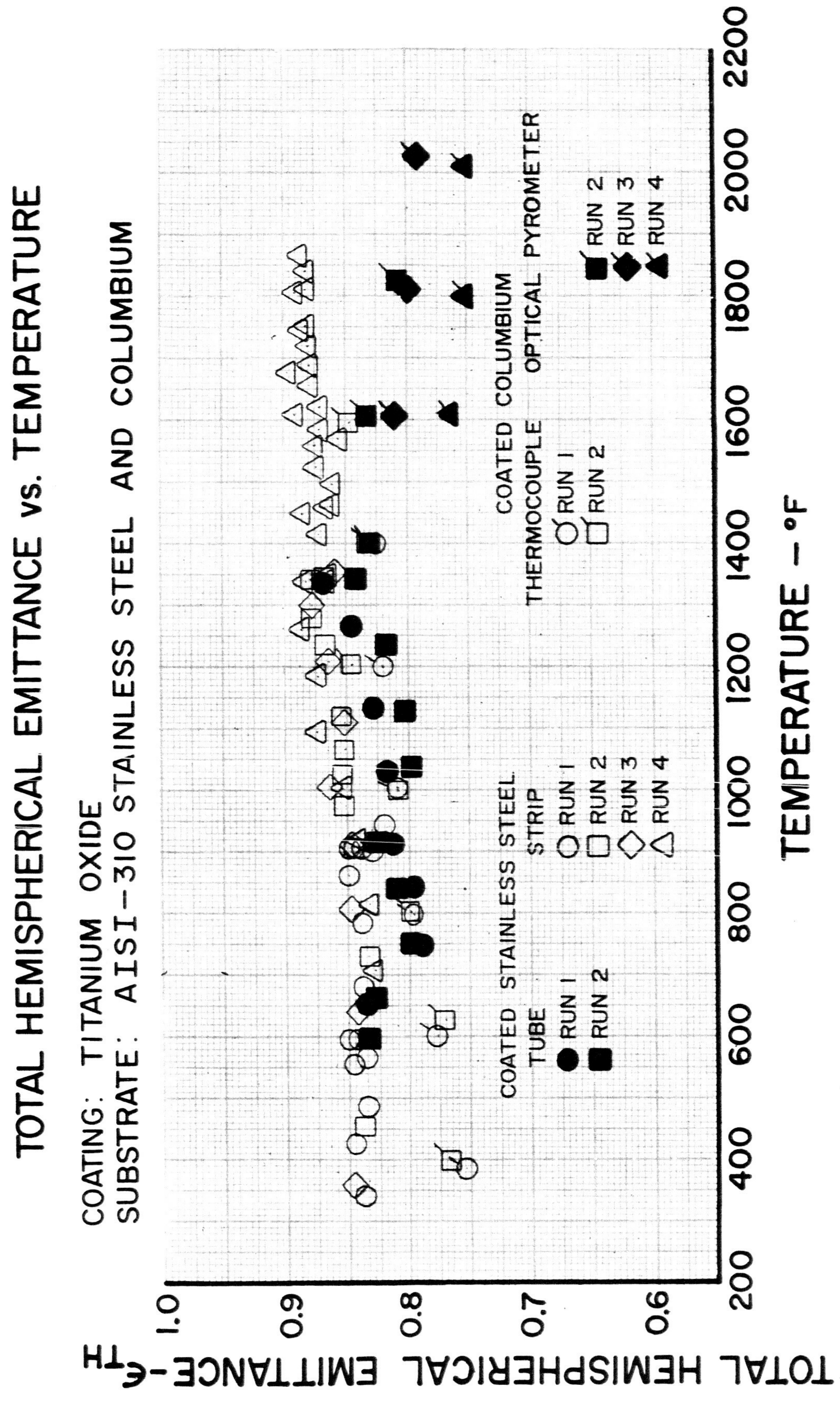

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: TITANIUM OXIDE
SUBSTRATE: AISI-310 STAINLESS STEEL AND COLUMBIUM
COATED STAINLESS TUBE
RUN 1
RUN 2
COATED STAINLESS STEEL STRIP
RUN 1
RUN 2
RUN 3
RUN 4
COATED COLUMBIUM
THERMOCOUPLE
RUN 1
RUN 2
OPTICAL PYROMETER
RUN 2
RUN 3
RUN 4
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 113 a

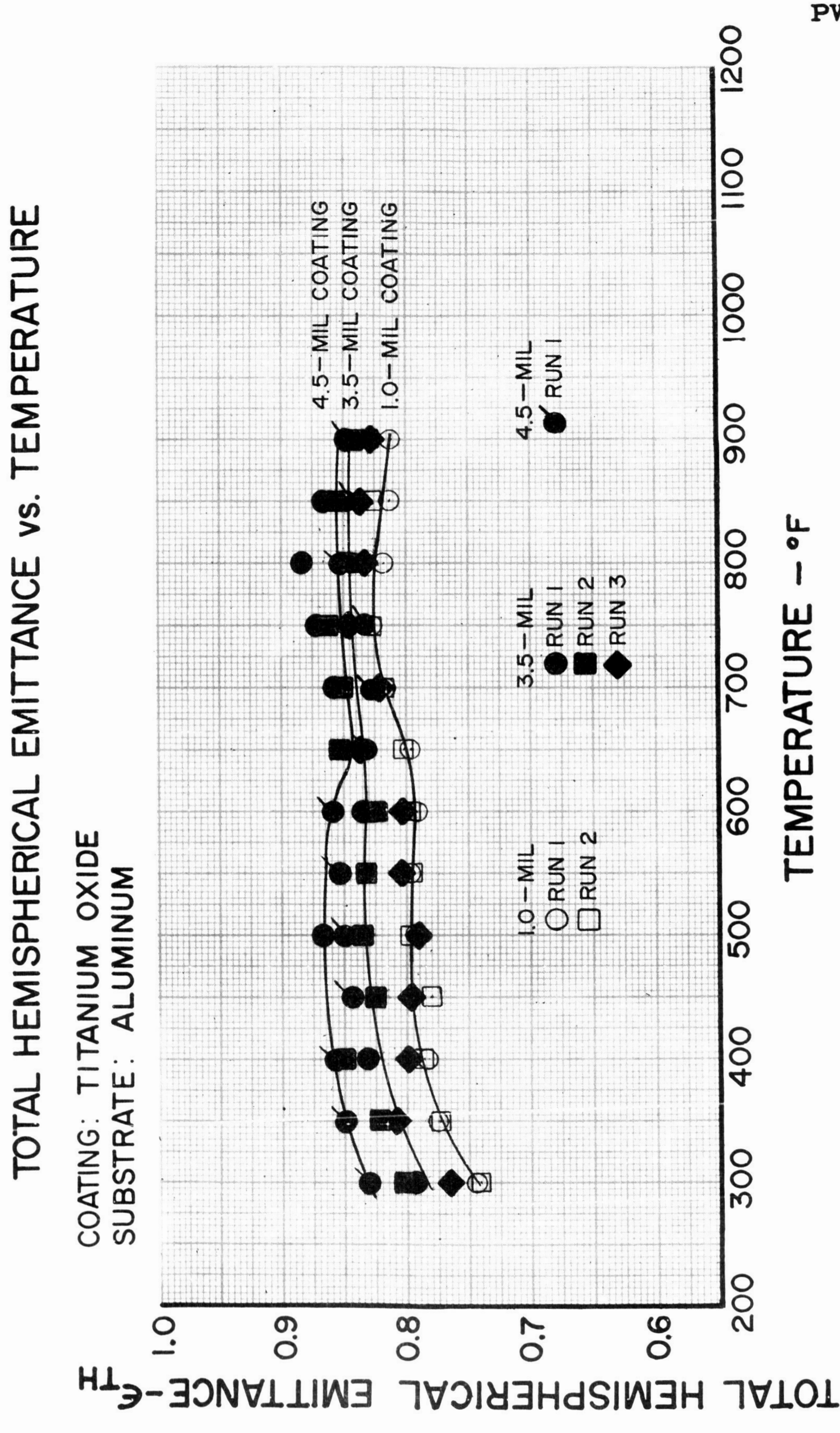

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: TITANIUM OXIDE
SUBSTRATE: ALUMINUM
4.5-MIL COATING
3.5-MIL COATING
1.0-MIL COATING
1.0-MIL
RUN 1
RUN 2
3.5-MIL
RUN 1
RUN 2
RUN 3
4.5-MIL
RUN 1
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
300
400
500
600
700
800
900
1000
1100
1200
TEMPERATURE — °F

Figure 113 b

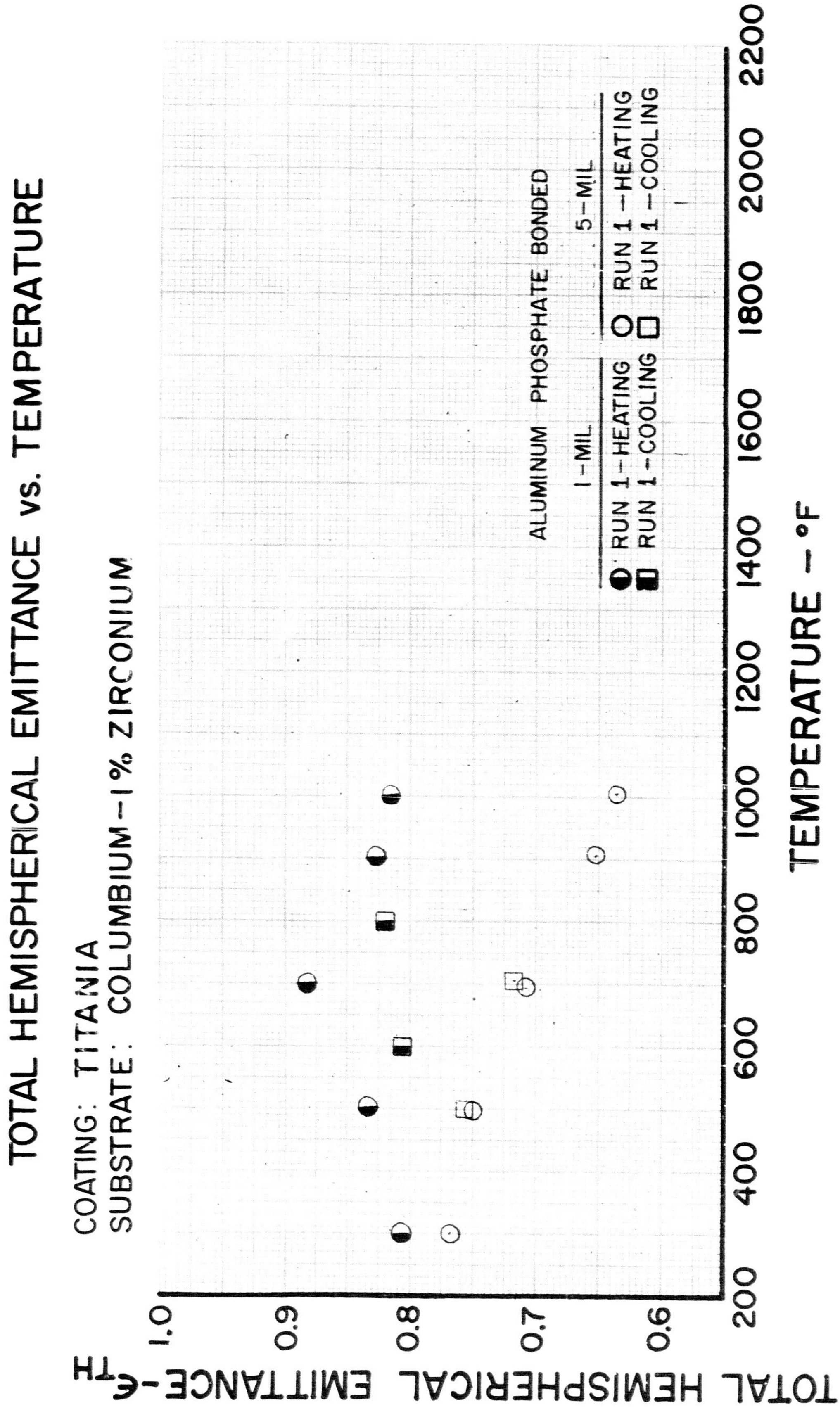

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: TITANIA
SUBSTRATE: COLUMBIUM-1% ZIRCONIUM
ALUMINUM PHOSPHATE BONDED
1-MIL
RUN 1-HEATING
RUN 1-COOLING
5-MIL
RUN 1-HEATING
RUN 1-COOLING
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 114

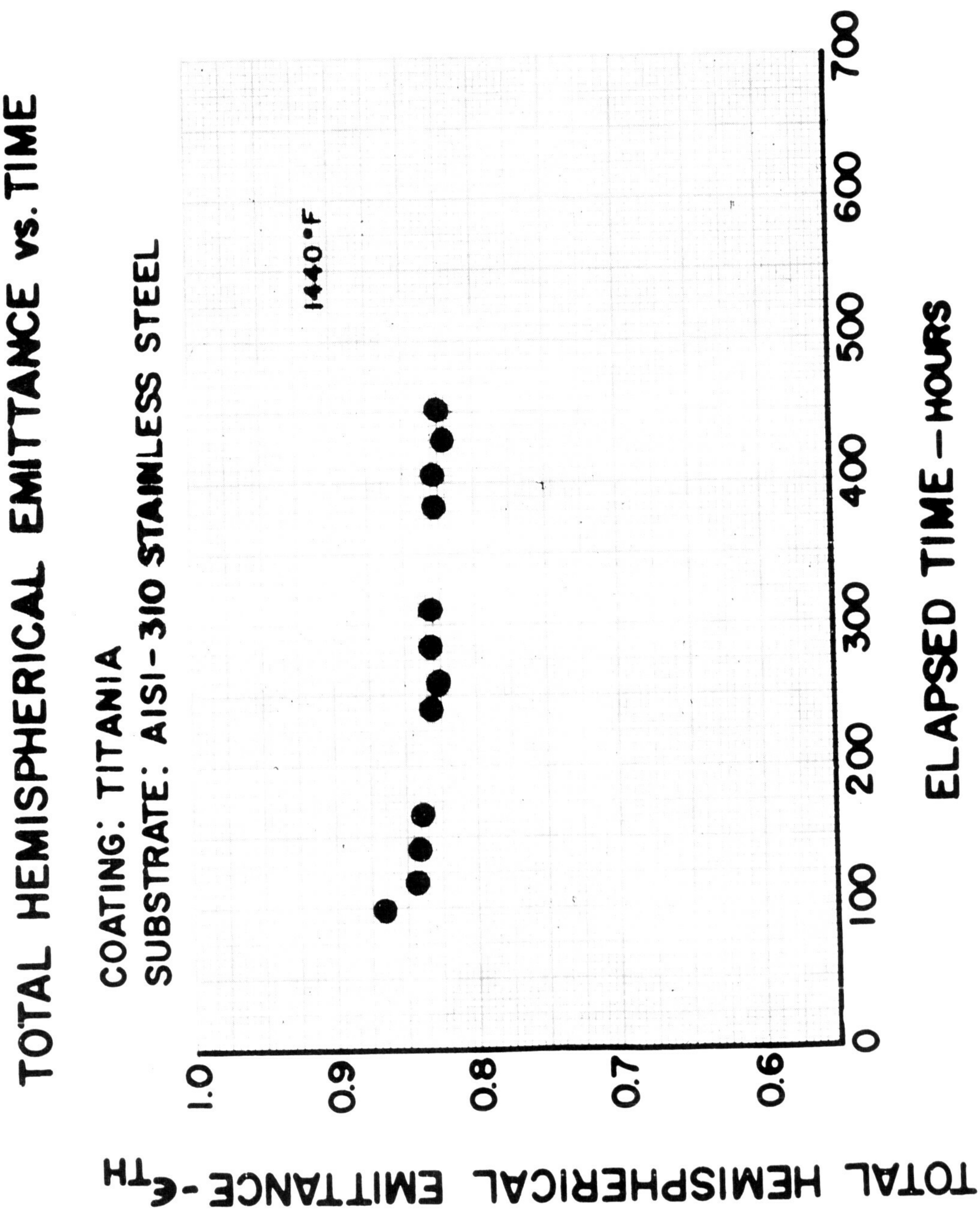

TOTAL HEMISPHERICAL EMITTANCE vs. TIME
COATING: TITANIA
SUBSTRATE: AISI-310 STAINLESS STEEL
1440°F
TOTAL HEMISPHERICAL EMITTANCE - ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
0
100
200
300
400
500
600
700
ELAPSED TIME — HOURS

Figure 115

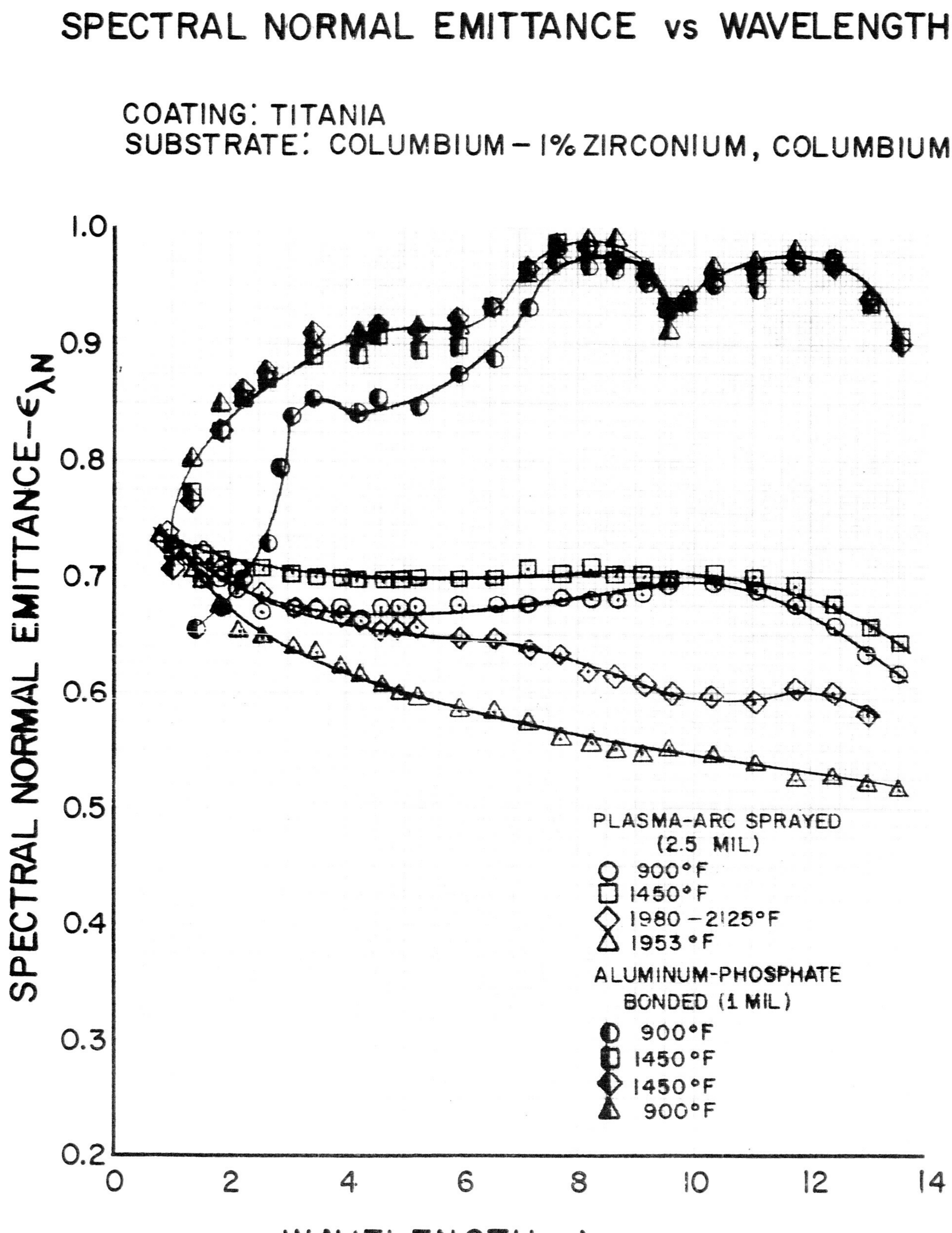

SPECTRAL NORMAL EMITTANCE vs WAVELENGTH
COATING: TITANIA
SUBSTRATE: COLUMBIUM - 1% ZIRCONIUM, COLUMBIUM
SPECTRAL NORMAL EMITTANCE - $\epsilon_{\lambda N}$
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
2
4
6
8
10
12
14
WAVELENGTH - λ - MICRONS
PLASMA-ARC SPRAYED
(2.5 MIL)
900°F
1450°F
1980 - 2125°F
1953 °F
ALUMINUM-PHOSPHATE
BONDED (1 MIL)
900°F
1450 °F
1450 °F
900°F

Figure 116

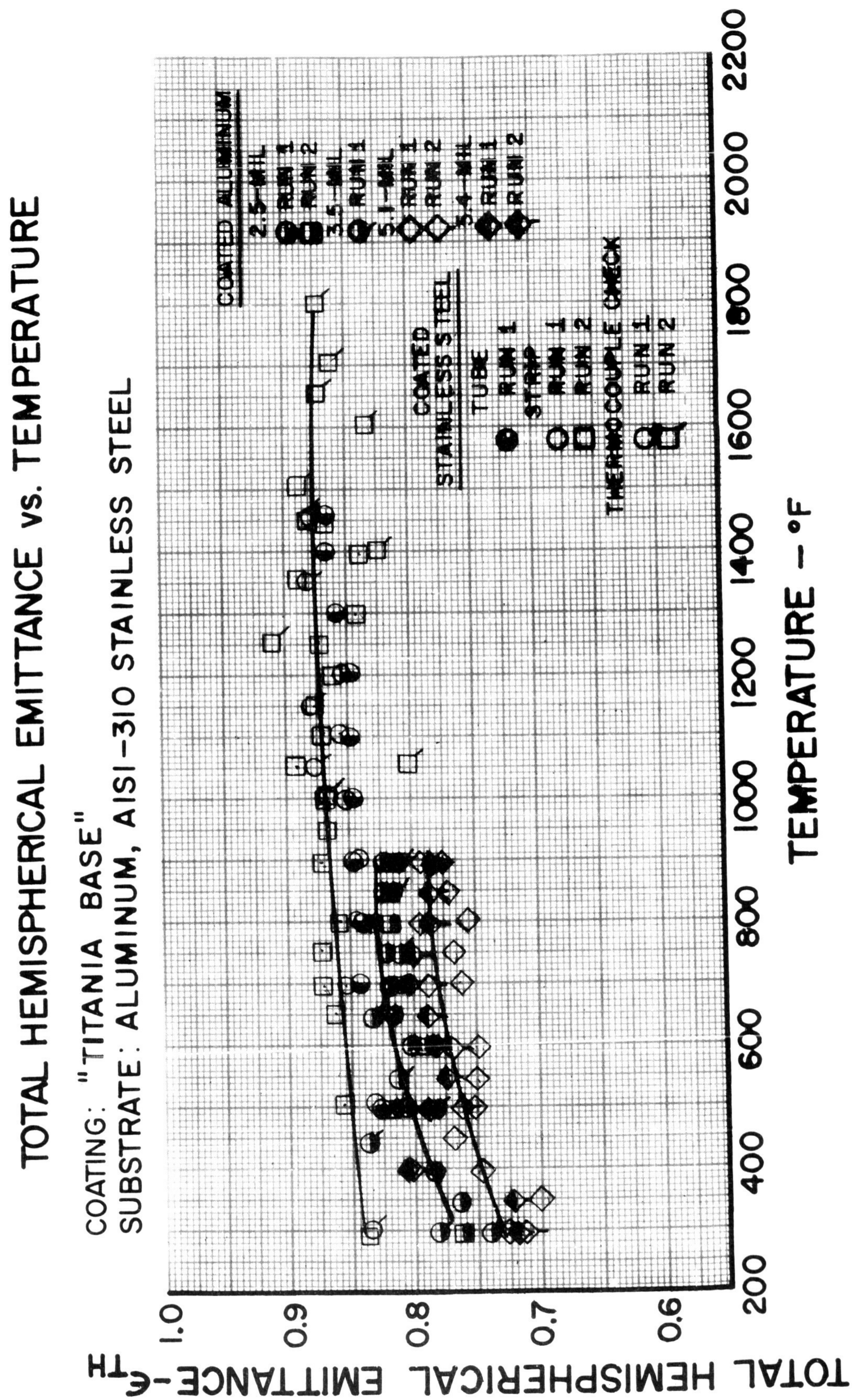

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: "TITANIA BASE"
SUBSTRATE: ALUMINUM, AISI-310 STAINLESS STEEL
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
TEMPERATURE — °F
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
COATED ALUMINUM
2.5-MIL
RUN 1
RUN 2
3.5-MIL
RUN 1
5.1-MIL
RUN 1
RUN 2
5.4-MIL
RUN 1
RUN 2
COATED STAINLESS STEEL
TUBE
RUN 1
STRIP
RUN 1
RUN 2
THERMOCOUPLE CHECK
RUN 1
RUN 2

Figure 117

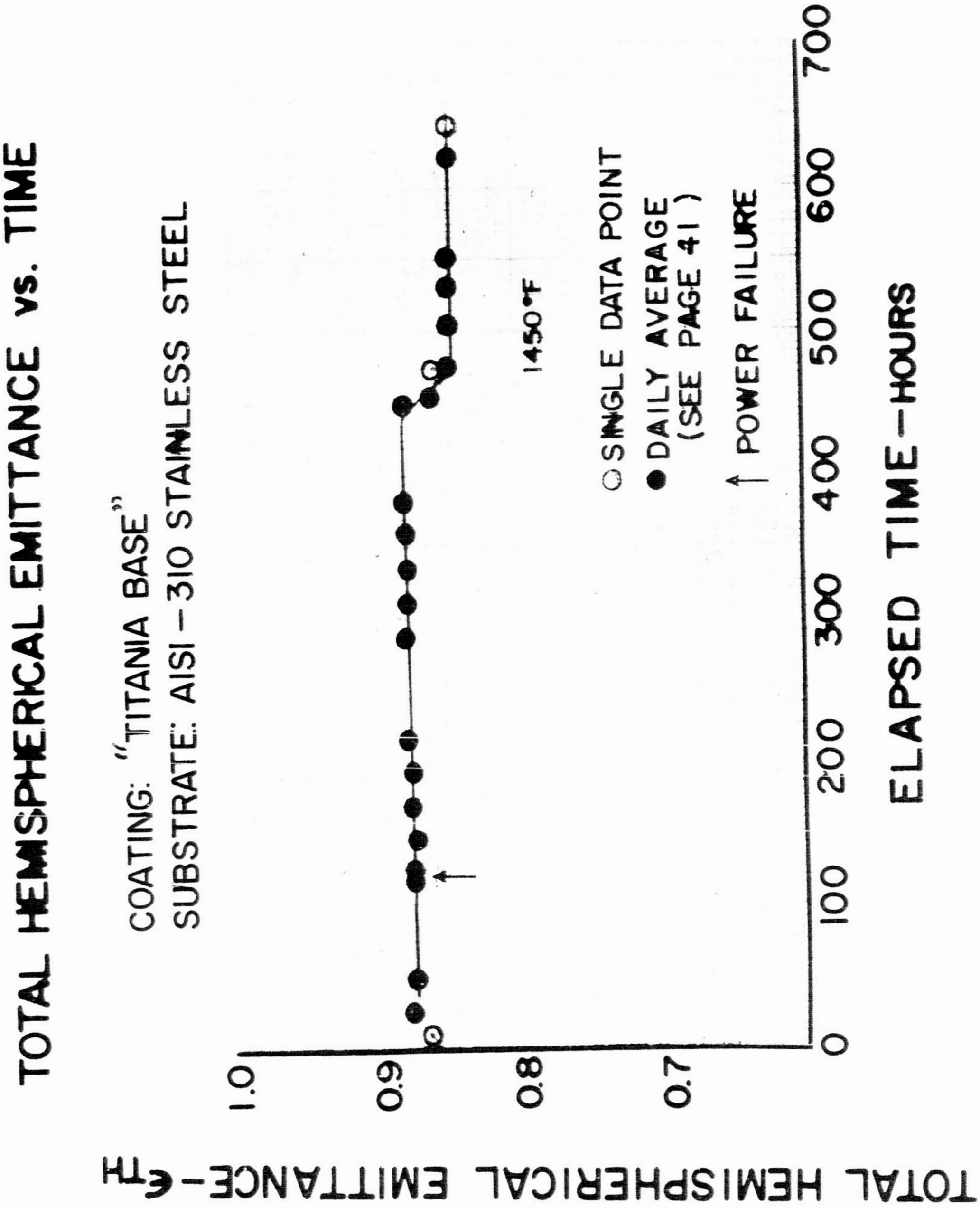
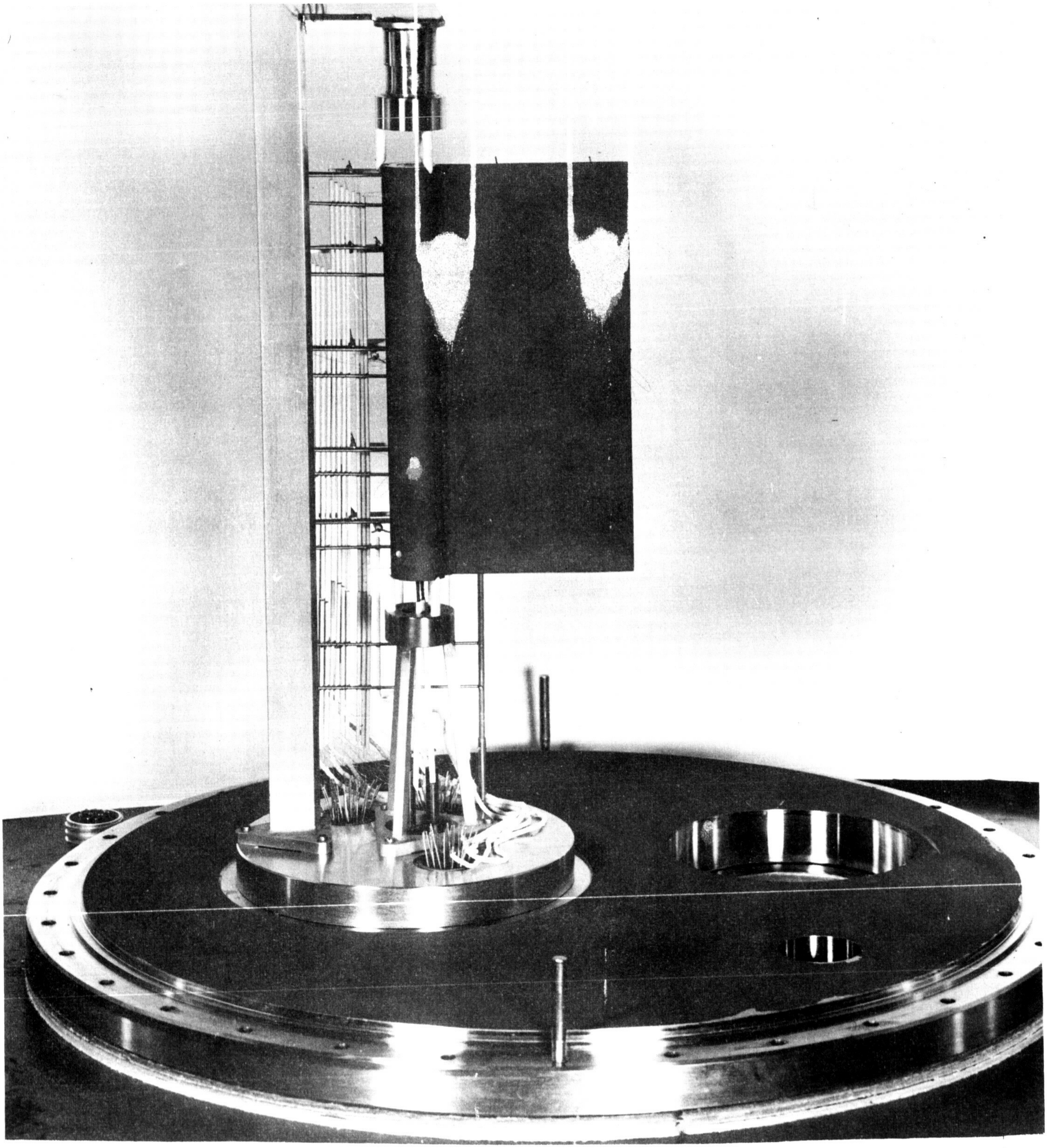
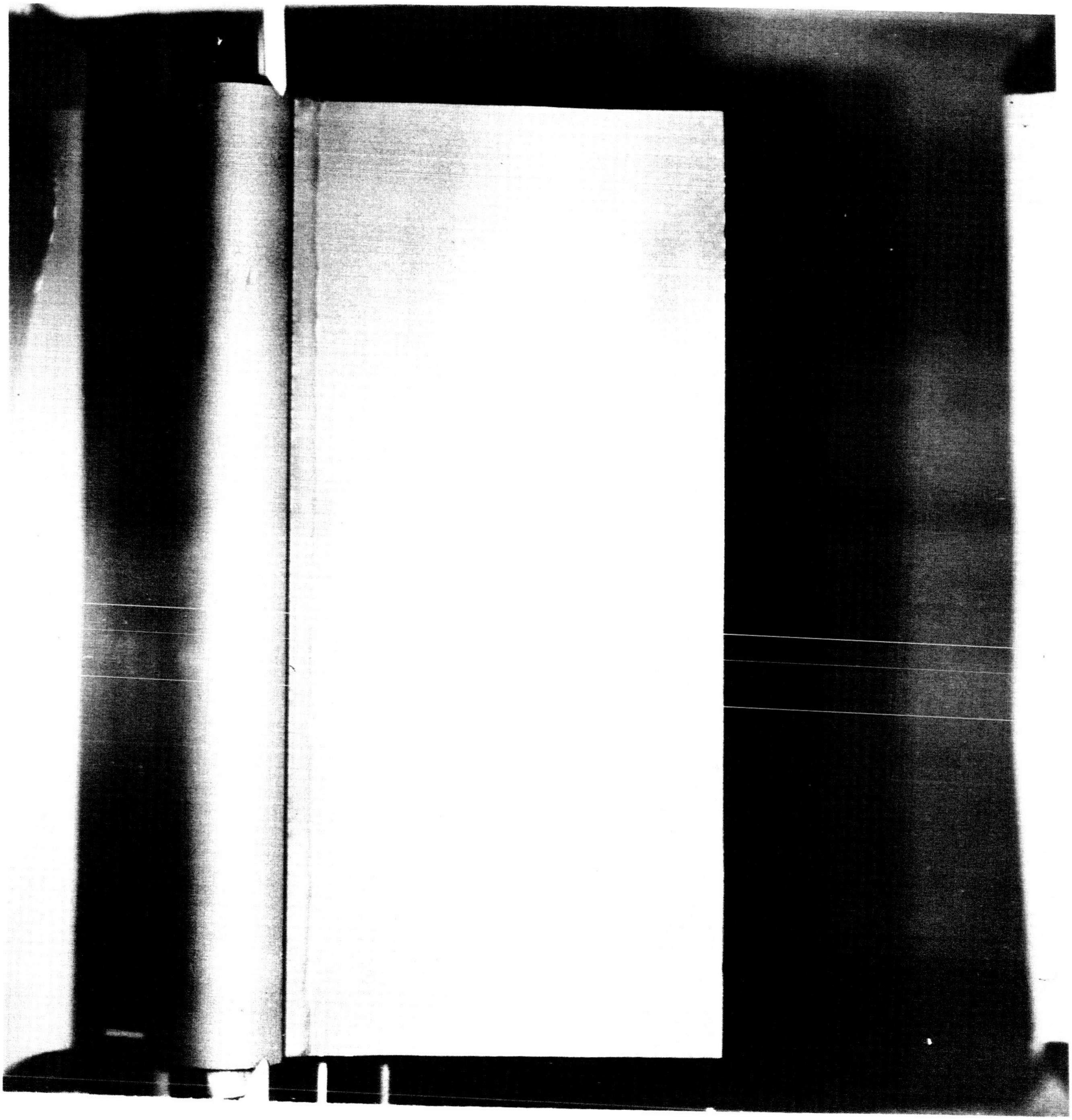

TOTAL HEMISPHERICAL EMITTANCE vs. TIME
COATING: "TITANIA BASE"
SUBSTRATE: AISI - 310 STAINLESS STEEL
1450°F
○ SINGLE DATA POINT
● DAILY AVERAGE (SEE PAGE 41)
↑ POWER FAILURE
TOTAL HEMISPHERICAL EMITTANCE - ϵ_{TH}
1.0
0.9
0.8
0.7
0
100
200
300
400
500
600
700
ELAPSED TIME - HOURS

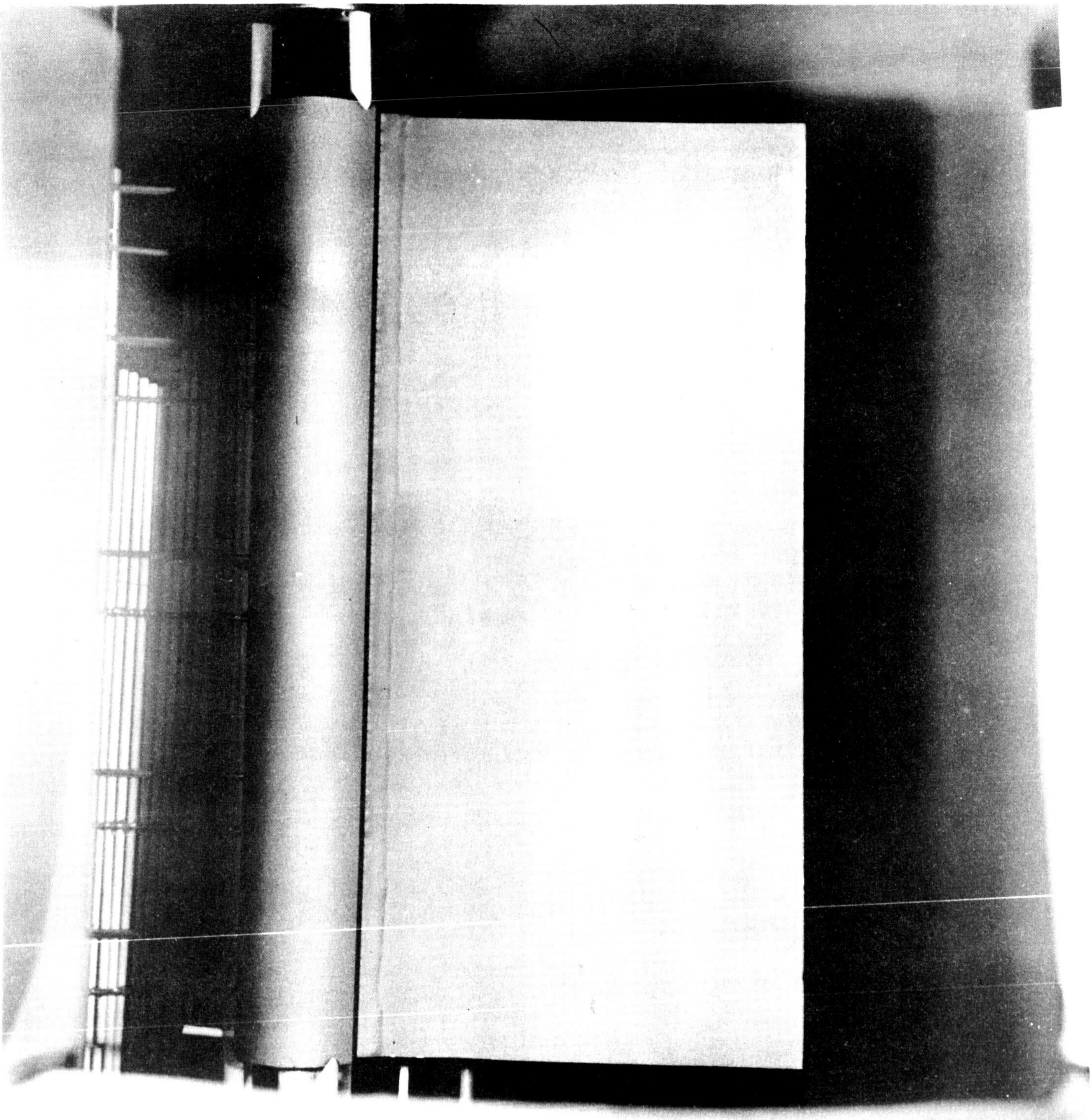
Figure 118



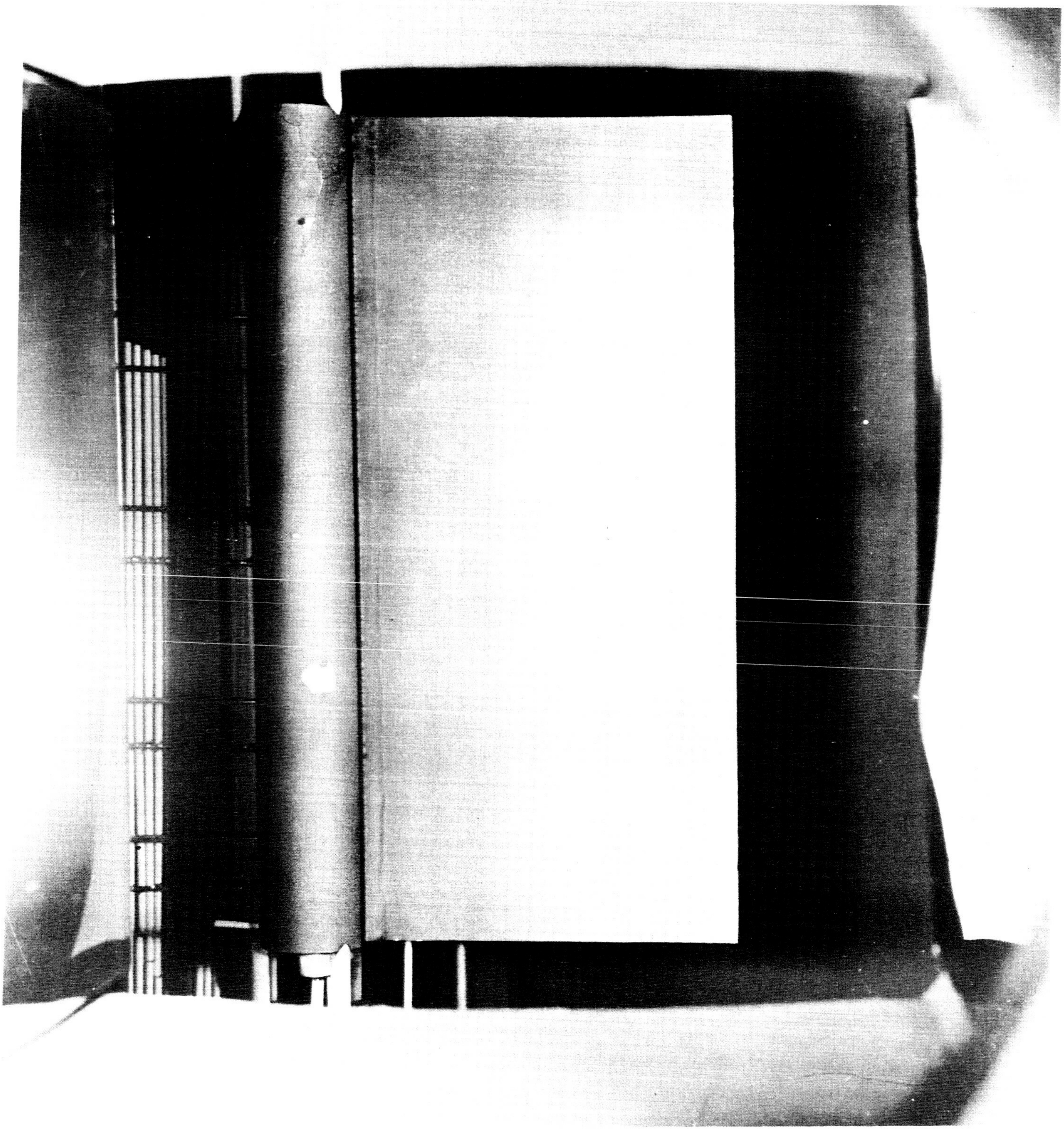
TITANIA - COATED SNAP-8 TEST SECTION BEFORE TESTING



TITANIA BASE COATED SNAP-8 FIN SEGMENT AFTER 2810 HOURS OF ENDURANCE TESTING

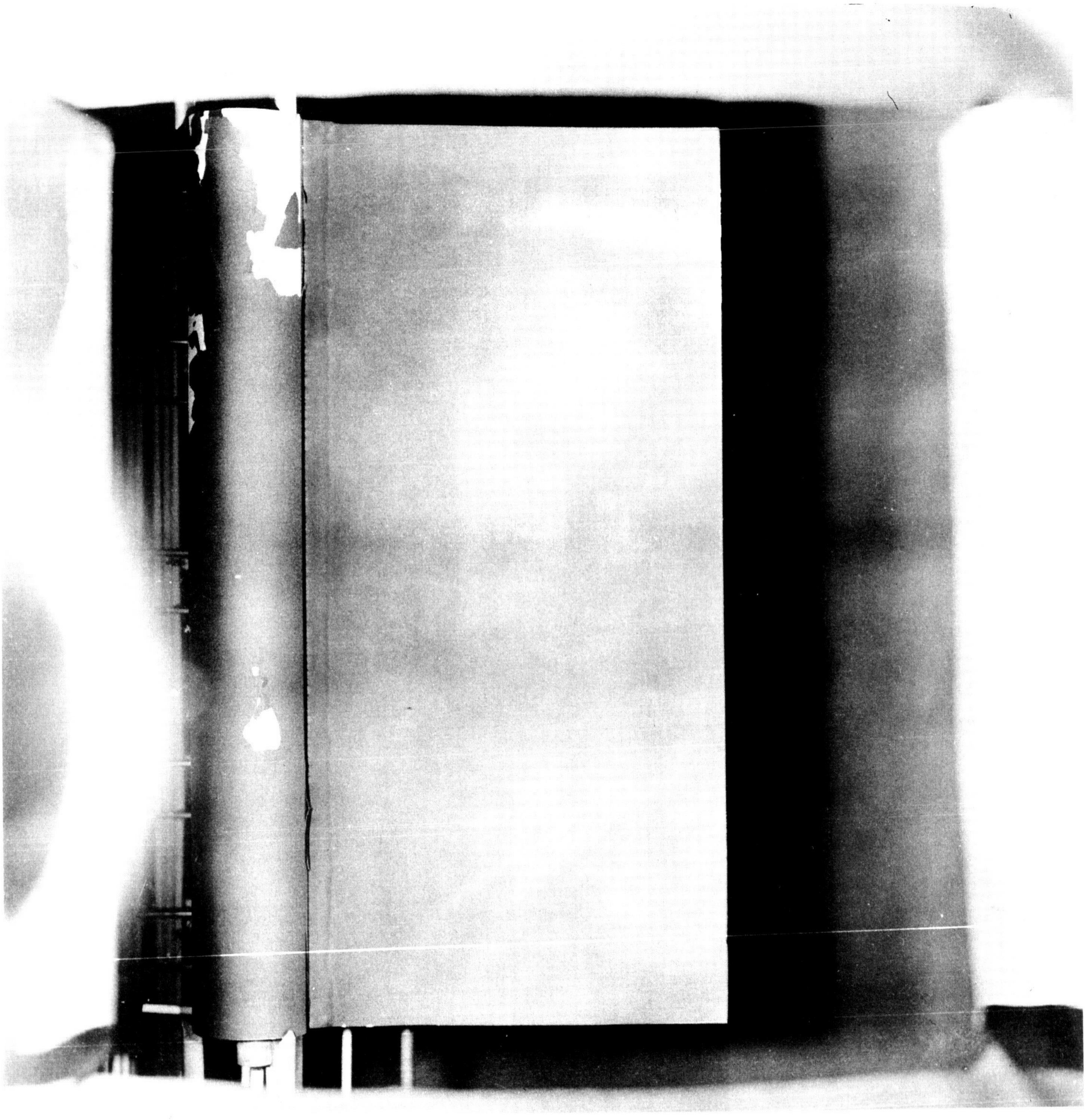


TITANIA BASE COATED SNAP-8 FIN SEGMENT AFTER 3490 HOURS OF ENDURANCE TESTING



TITANIA BASE COATED SNAP-8 TEST SECTION AFTER 6840 HOURS OF ENDURANCE TESTING. NOTE LOSS OF COATING ON TUBE PORTION OF SPECIMEN

Figure 122

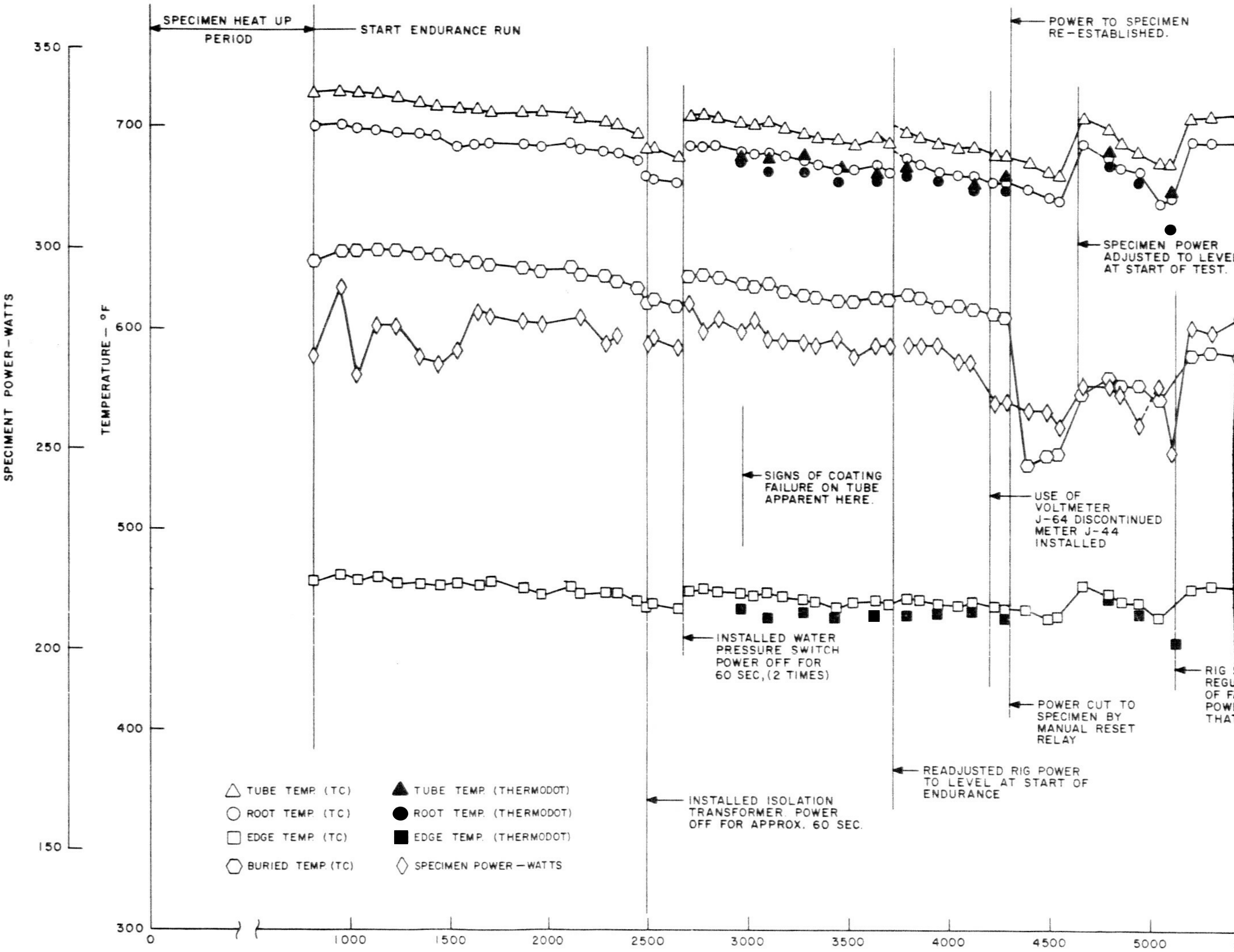


TITANIA BASE COATED SNAP-8 TEST SECTION AFTER APPROXIMATELY 8300 HOURS OF ENDURANCE TESTING. NOTE LOSS OF COATING ON THE TUBE PORTION OF THE SPECIMEN AND FLAKING AT THE TUBE-FIN JUNCTION

Figure 123

LONG TERM EN

TITANIA BASE COATING O



124 ⓪

DURANCE TEST
SNAP-8 TEST SECTION

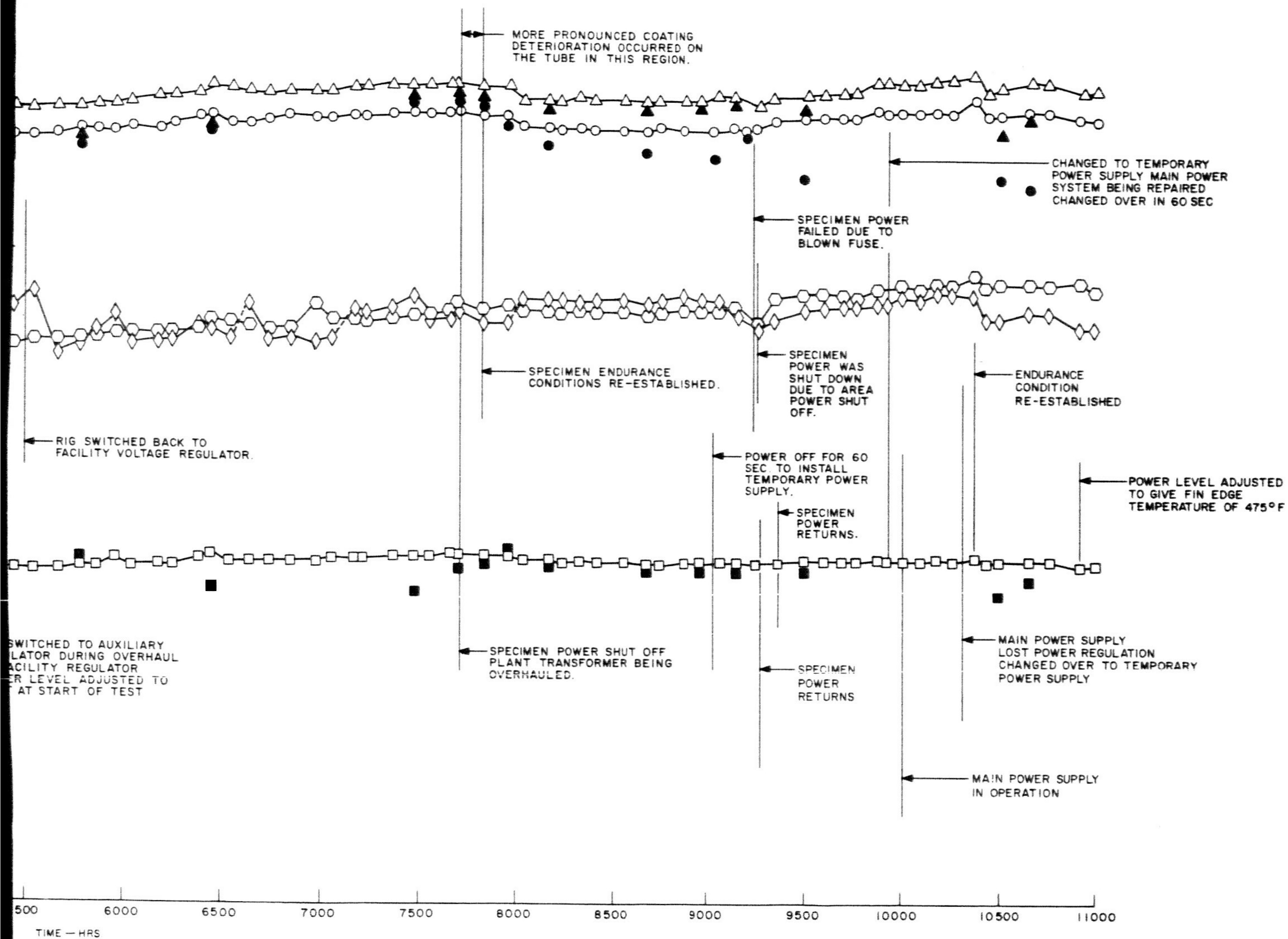
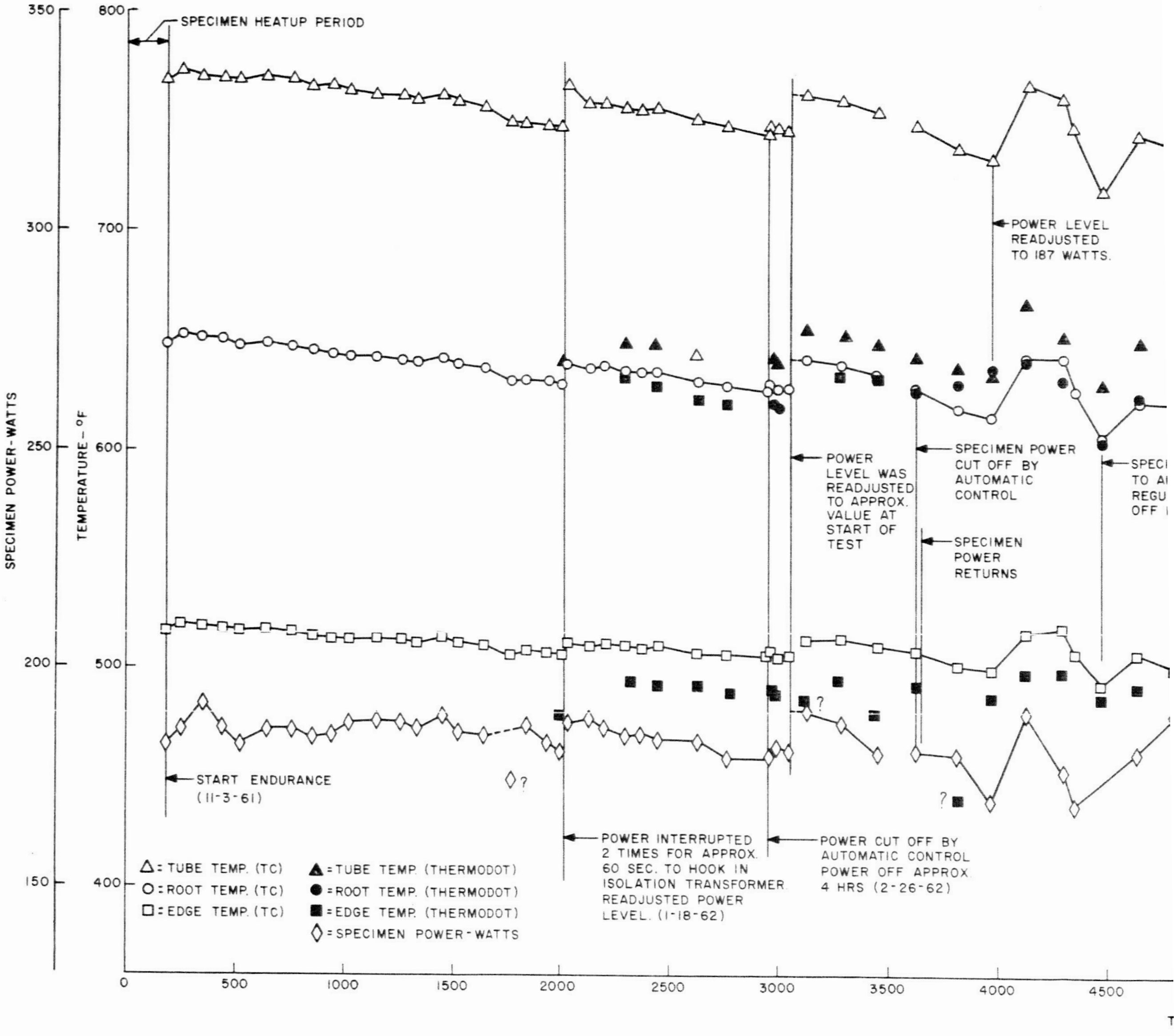


Figure 124

2

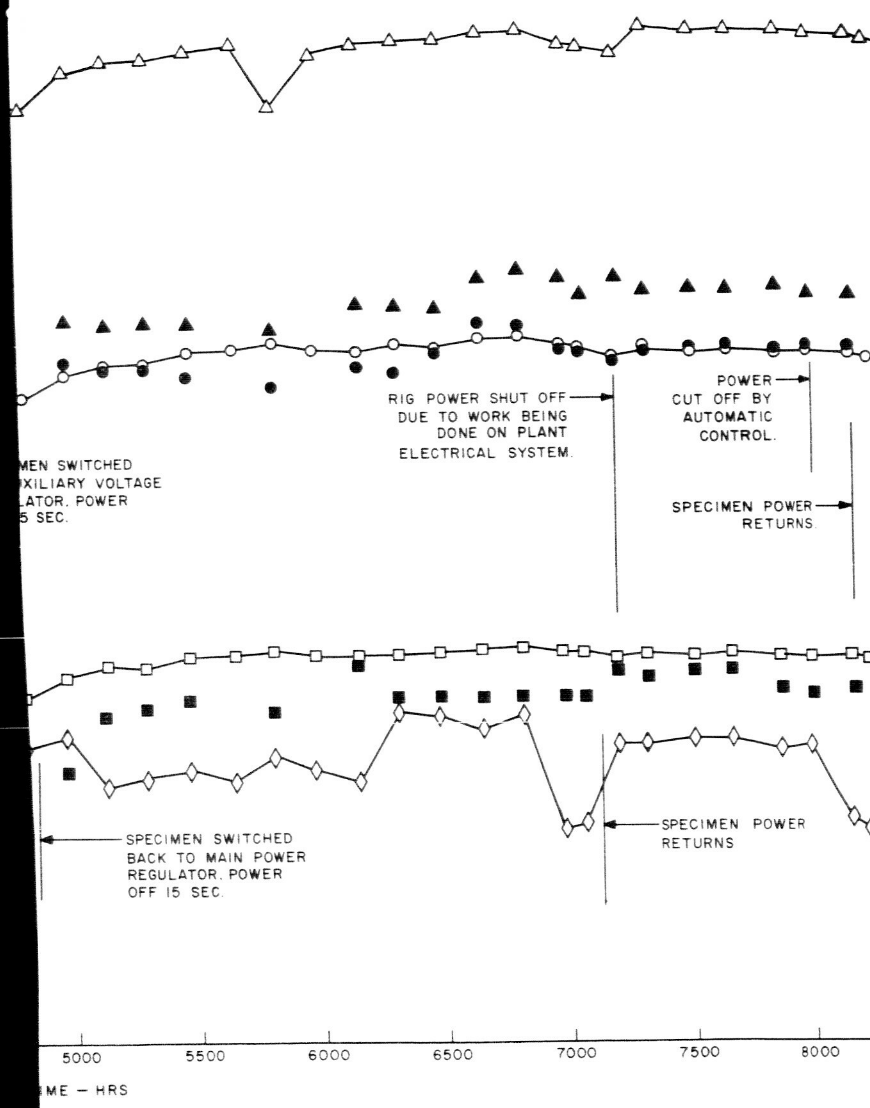
TITANIA-BASE COATED SUNFLOWER I TEST SECTION AFTER 9914 HOURS OF ENDURANCE TESTING

TITANIA BAS



126 (1)

LONG TERM ENDURANCE TEST
E COATING ON SUNFLOWER I TEST SECTION



2

126

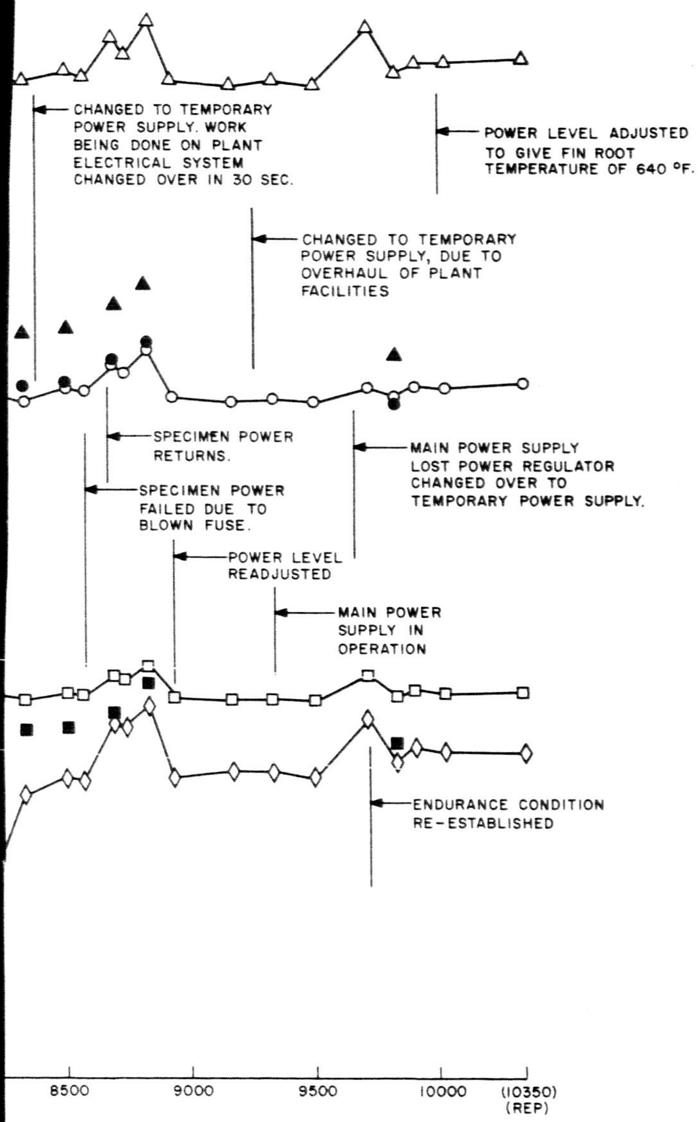

CHANGED TO TEMPORARY POWER SUPPLY. WORK BEING DONE ON PLANT ELECTRICAL SYSTEM CHANGED OVER IN 30 SEC.
POWER LEVEL ADJUSTED TO GIVE FIN ROOT TEMPERATURE OF 640 °F.
CHANGED TO TEMPORARY POWER SUPPLY, DUE TO OVERHAUL OF PLANT FACILITIES
SPECIMEN POWER RETURNS.
MAIN POWER SUPPLY LOST POWER REGULATOR CHANGED OVER TO TEMPORARY POWER SUPPLY.
SPECIMEN POWER FAILED DUE TO BLOWN FUSE.
POWER LEVEL READJUSTED
MAIN POWER SUPPLY IN OPERATION
ENDURANCE CONDITION RE-ESTABLISHED
8500
9000
9500
10000
(10350)
(REP)

Figure 126

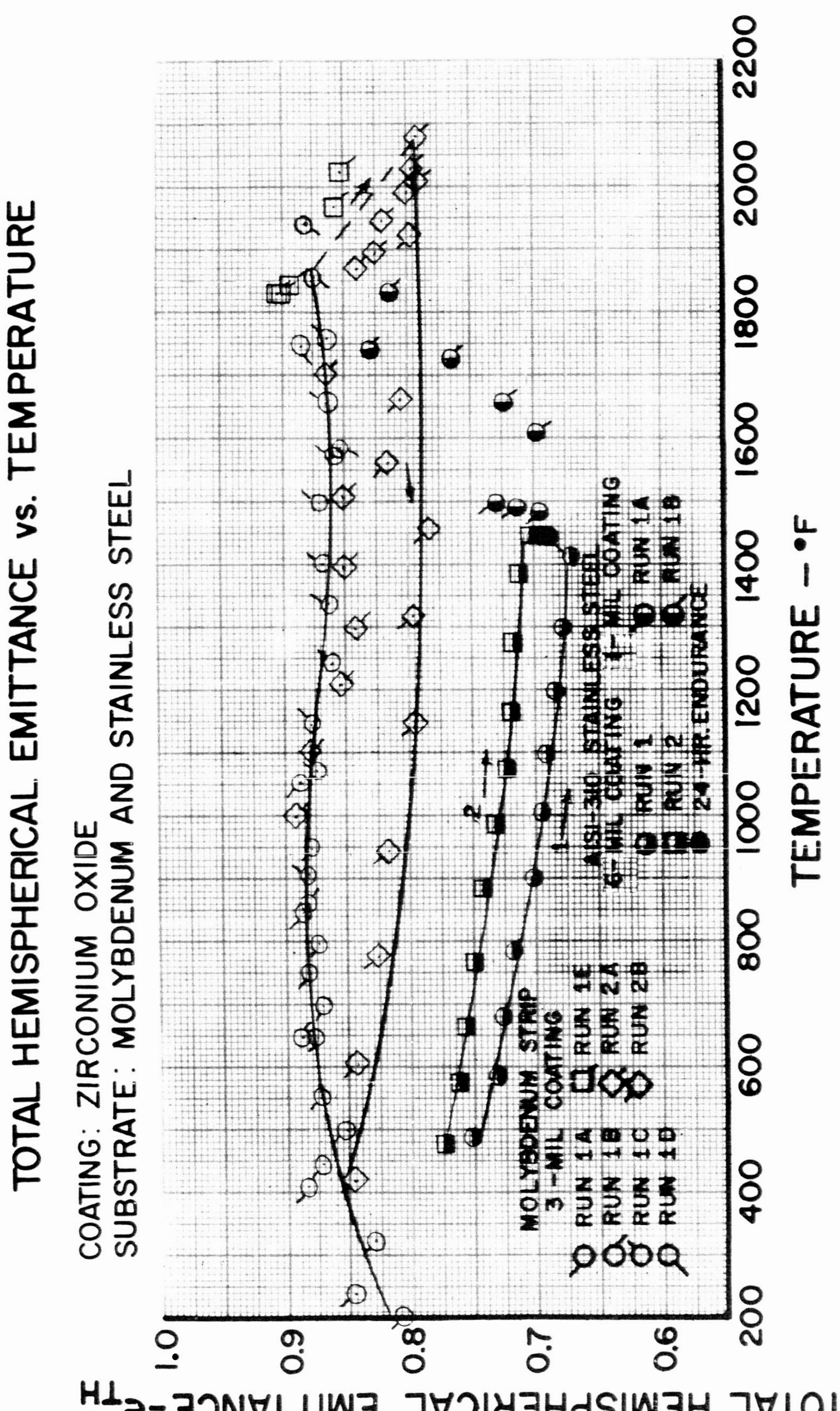

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: ZIRCONIUM OXIDE
SUBSTRATE: MOLYBDENUM AND STAINLESS STEEL
MOLYBDENUM STRIP
3-MIL COATING
RUN 1A
RUN 1B
RUN 1C
RUN 1D
RUN 1E
RUN 2A
RUN 2B
AISI-310 STAINLESS STEEL
6-MIL COATING
1-MIL COATING
RUN 1
RUN 2
24-HR. ENDURANCE
RUN 1A
RUN 1B
1
2
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}

Figure 127

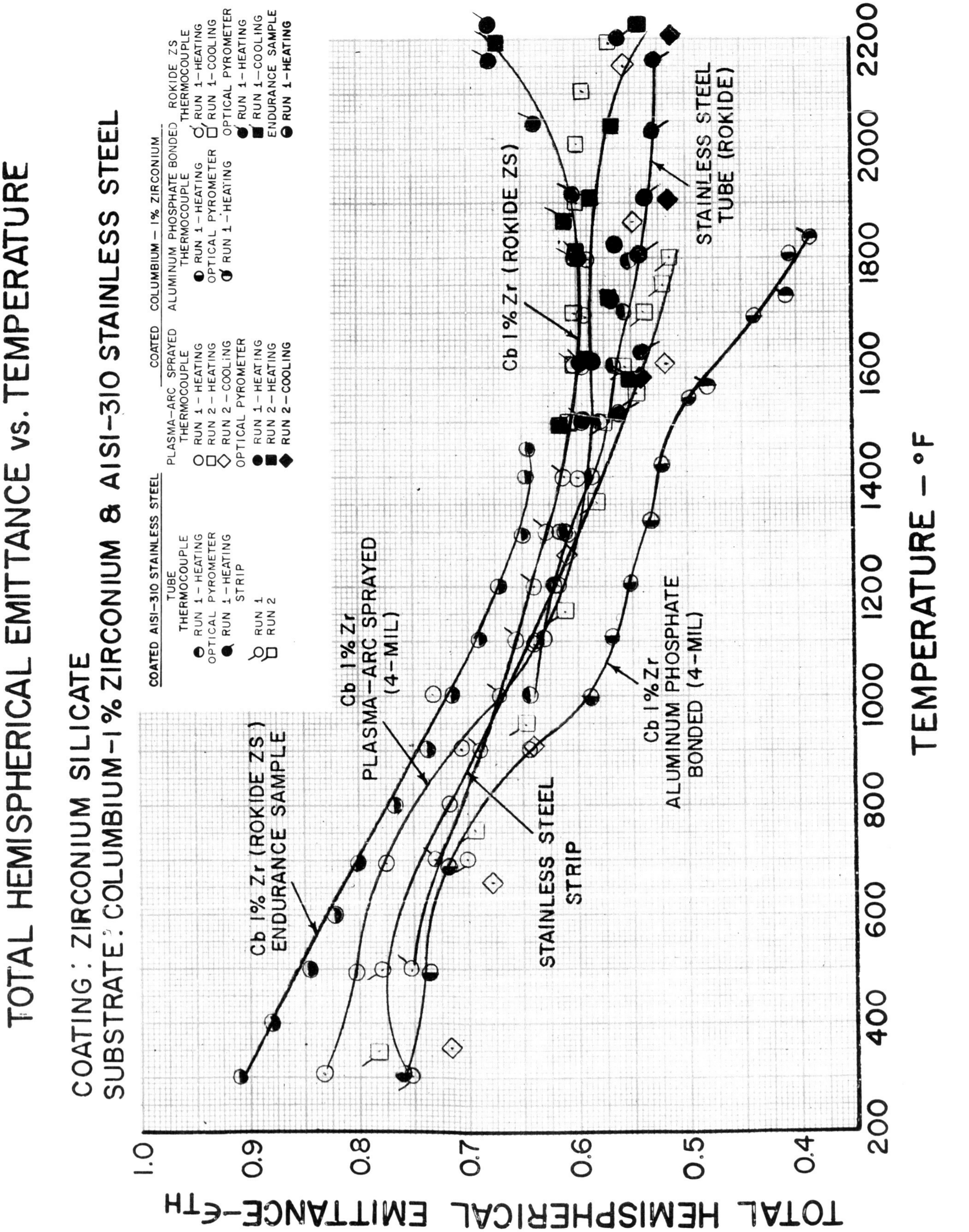
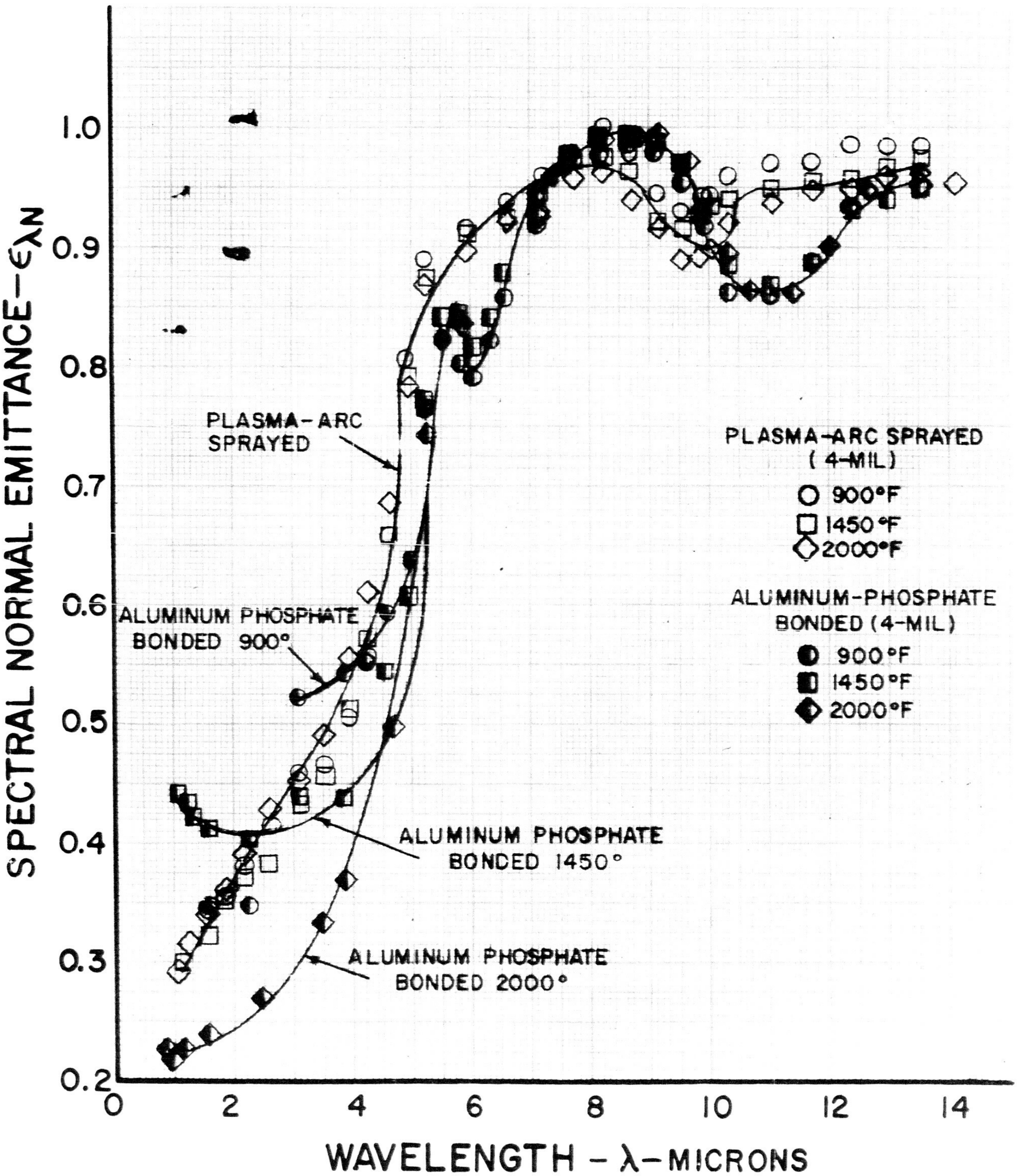

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: ZIRCONIUM SILICATE
SUBSTRATE: COLUMBIUM-1% ZIRCONIUM & AISI-310 STAINLESS STEEL
COATED AISI-310 STAINLESS STEEL
TUBE
THERMOCOUPLE
RUN 1 - HEATING
OPTICAL PYROMETER
RUN 1 - HEATING
STRIP
RUN 1
RUN 2
COATED COLUMBIUM - 1% ZIRCONIUM
PLASMA-ARC SPRAYED
THERMOCOUPLE
RUN 1 - HEATING
RUN 2 - HEATING
RUN 2 - COOLING
OPTICAL PYROMETER
RUN 1 - HEATING
RUN 2 - HEATING
RUN 2 - COOLING
ALUMINUM PHOSPHATE BONDED
THERMOCOUPLE
RUN 1 - HEATING
OPTICAL PYROMETER
RUN 1 - HEATING
ROKIDE ZS
THERMOCOUPLE
RUN 1 - HEATING
RUN 1 - COOLING
OPTICAL PYROMETER
RUN 1 - HEATING
RUN 1 - COOLING
ENDURANCE SAMPLE
RUN 1 - HEATING
Cb 1% Zr (ROKIDE ZS) ENDURANCE SAMPLE
Cb 1% Zr PLASMA-ARC SPRAYED (4-MIL)
STAINLESS STEEL STRIP
Cb 1% Zr (ROKIDE ZS)
Cb 1% Zr ALUMINUM PHOSPHATE BONDED (4-MIL)
STAINLESS STEEL TUBE (ROKIDE)
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
0.5
0.4
TEMPERATURE — °F
200
400
600
800
1000
1200
1400
1600
1800
2000
2200

Figure 128

SPECTRAL NORMAL EMITTANCE vs. WAVELENGTH

COATING: ZIRCONIUM SILICATE
SUBSTRATE: COLUMBIUM - 1% ZIRCONIUM



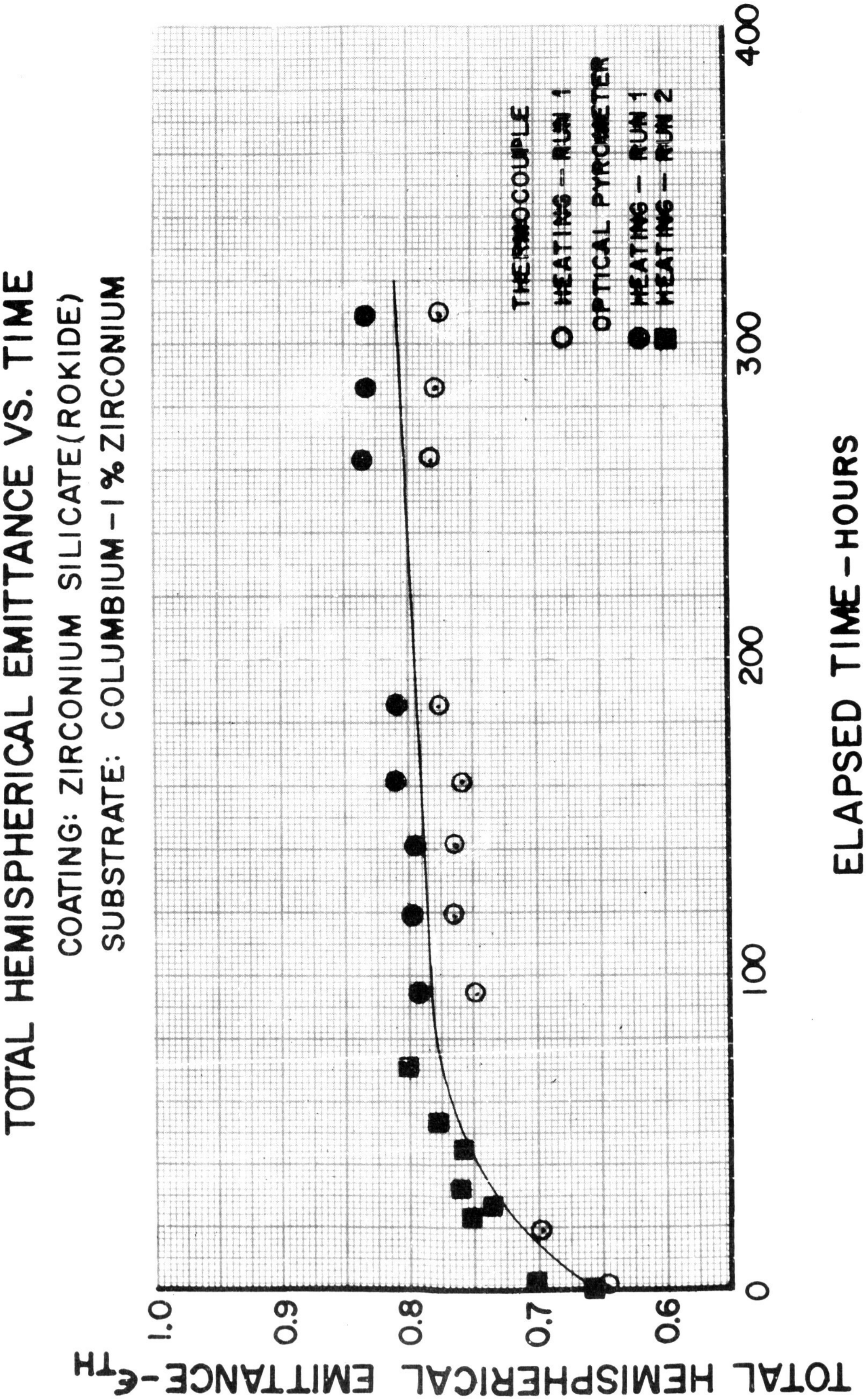

TOTAL HEMISPHERICAL EMITTANCE VS. TIME
COATING: ZIRCONIUM SILICATE (ROKIDE)
SUBSTRATE: COLUMBIUM-1% ZIRCONIUM
THERMOCOUPLE
HEATING -- RUN 1
OPTICAL PYROMETER
HEATING -- RUN 1
HEATING -- RUN 2
1.0
0.9
0.8
0.7
0.6
0
100
200
300
400
ELAPSED TIME-HOURS
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}

Figure 130

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE

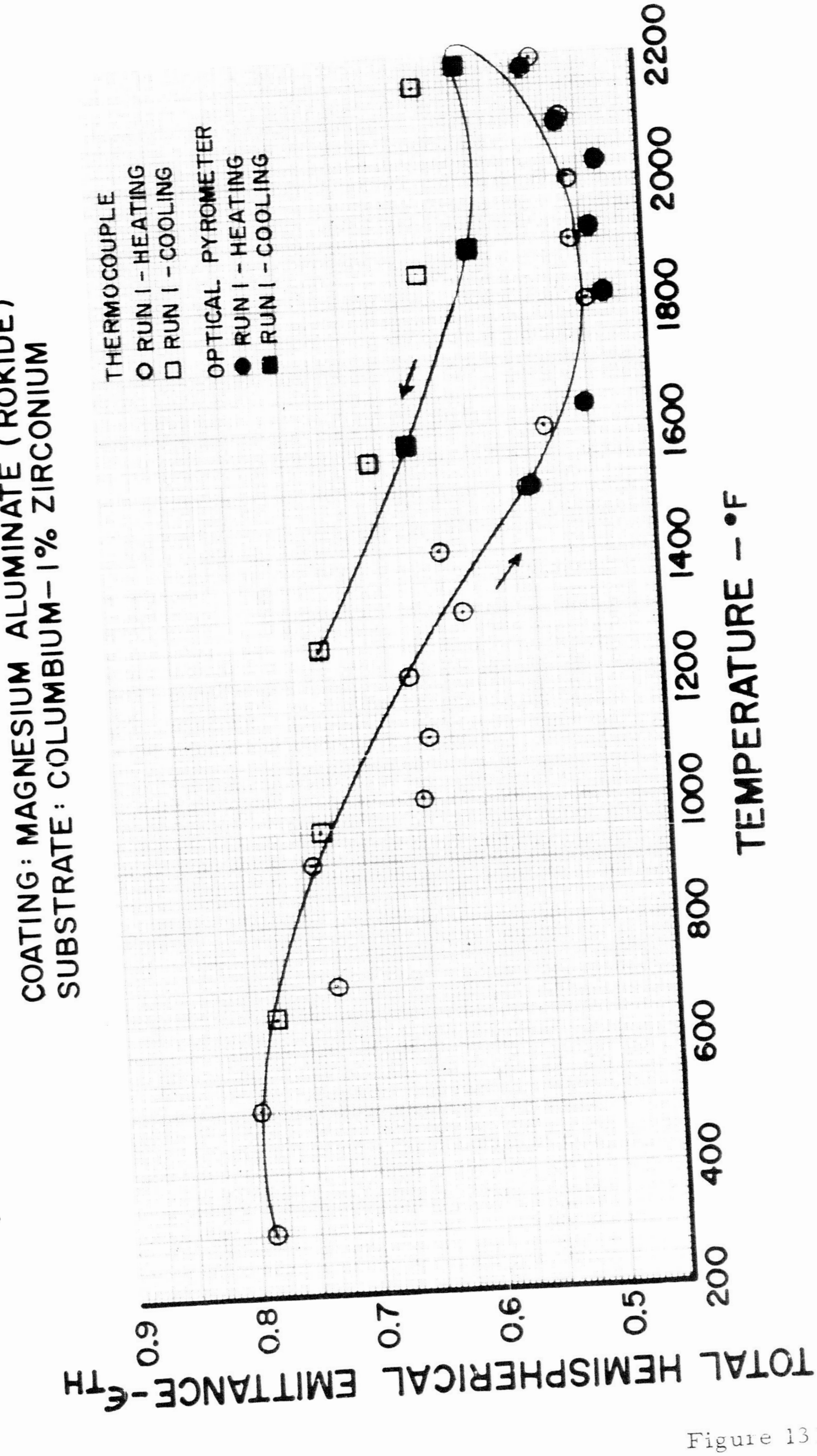
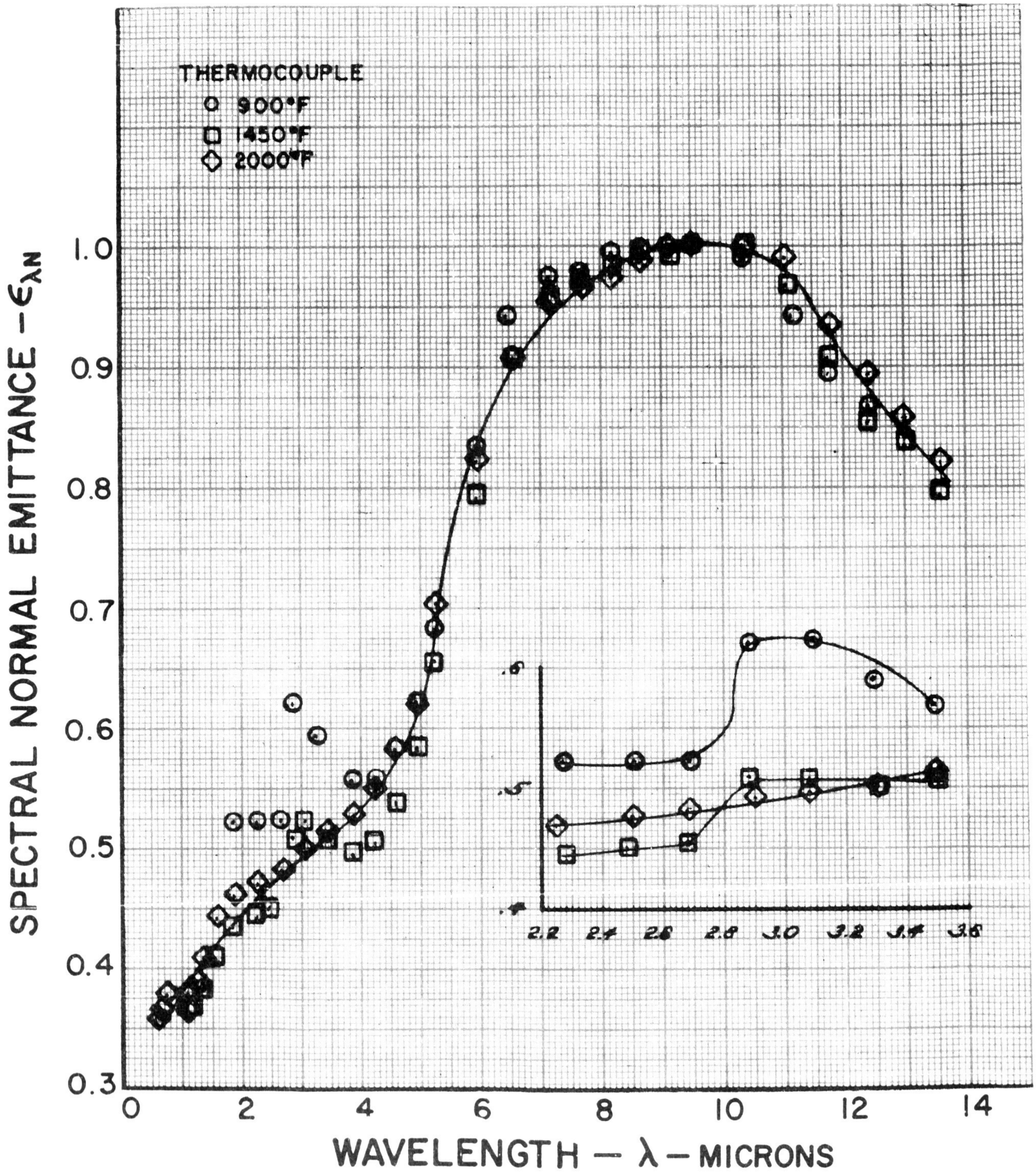
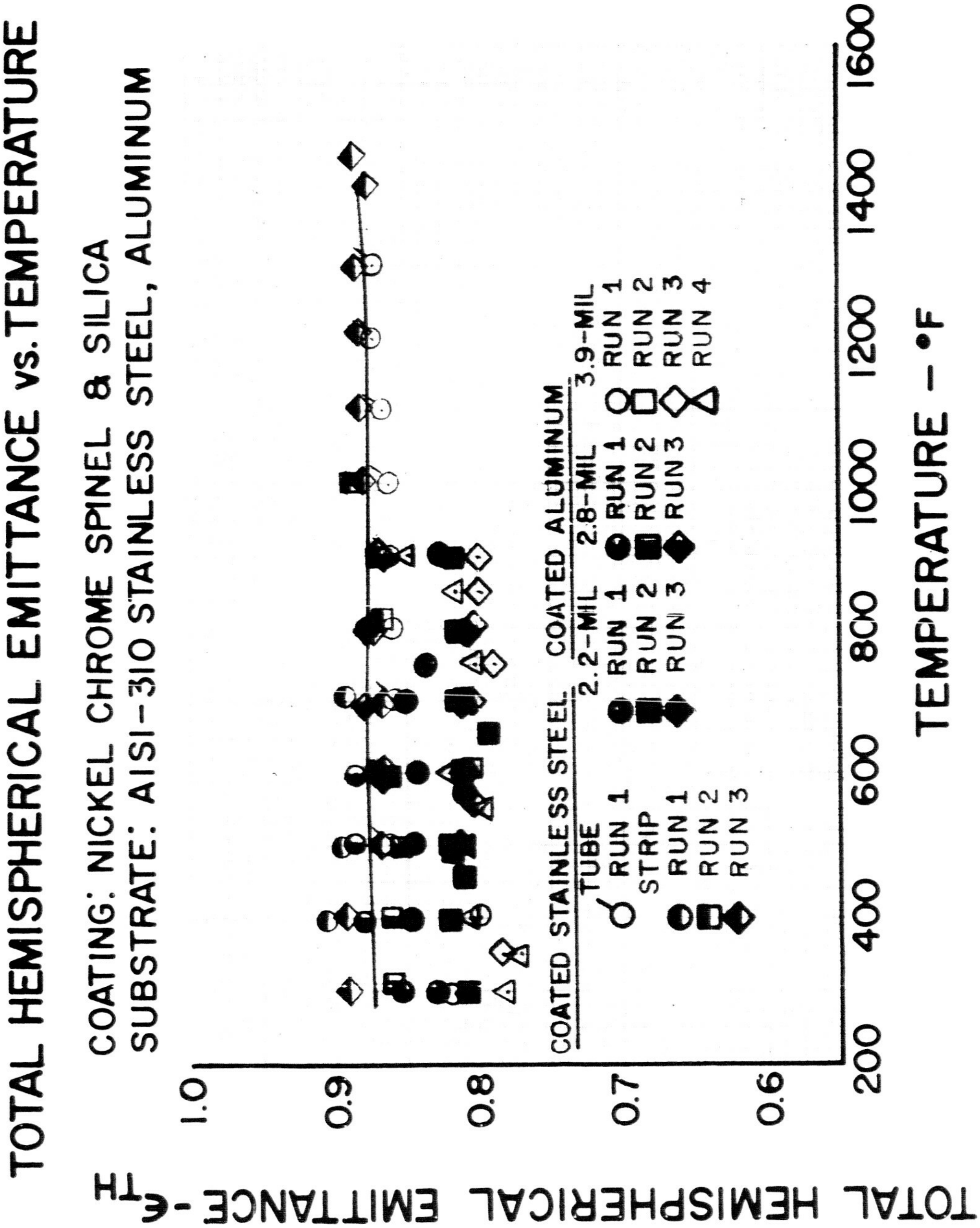


Figure 131

SPECTRAL NORMAL EMITTANCE vs WAVE LENGTH

COATING: MAGNESIUM ALUMINATE (ROKIDE)
SUBSTRATE: COLUMBIUM-1% ZIRCONIUM





TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: NICKEL CHROME SPINEL & SILICA
SUBSTRATE: AISI-310 STAINLESS STEEL, ALUMINUM
TOTAL HEMISPHERICAL EMITTANCE - ε TH
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
TEMPERATURE - °F
COATED STAINLESS STEEL
TUBE
RUN 1
STRIP
RUN 1
RUN 2
RUN 3
COATED ALUMINUM
2.2-MIL
RUN 1
RUN 2
RUN 3
2.8-MIL
RUN 1
RUN 2
RUN 3
3.9-MIL
RUN 1
RUN 2
RUN 3
RUN 4

Figure 133

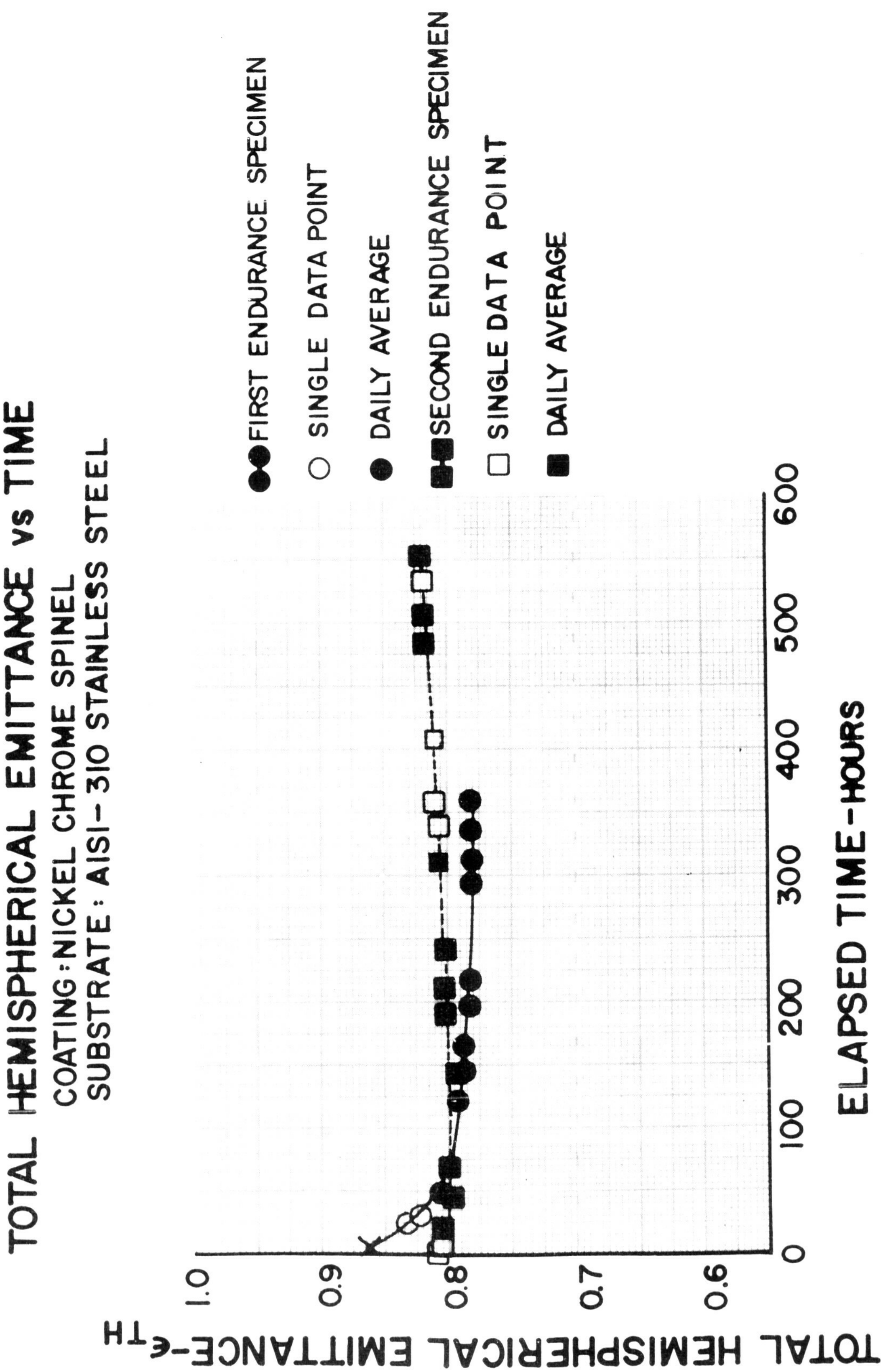
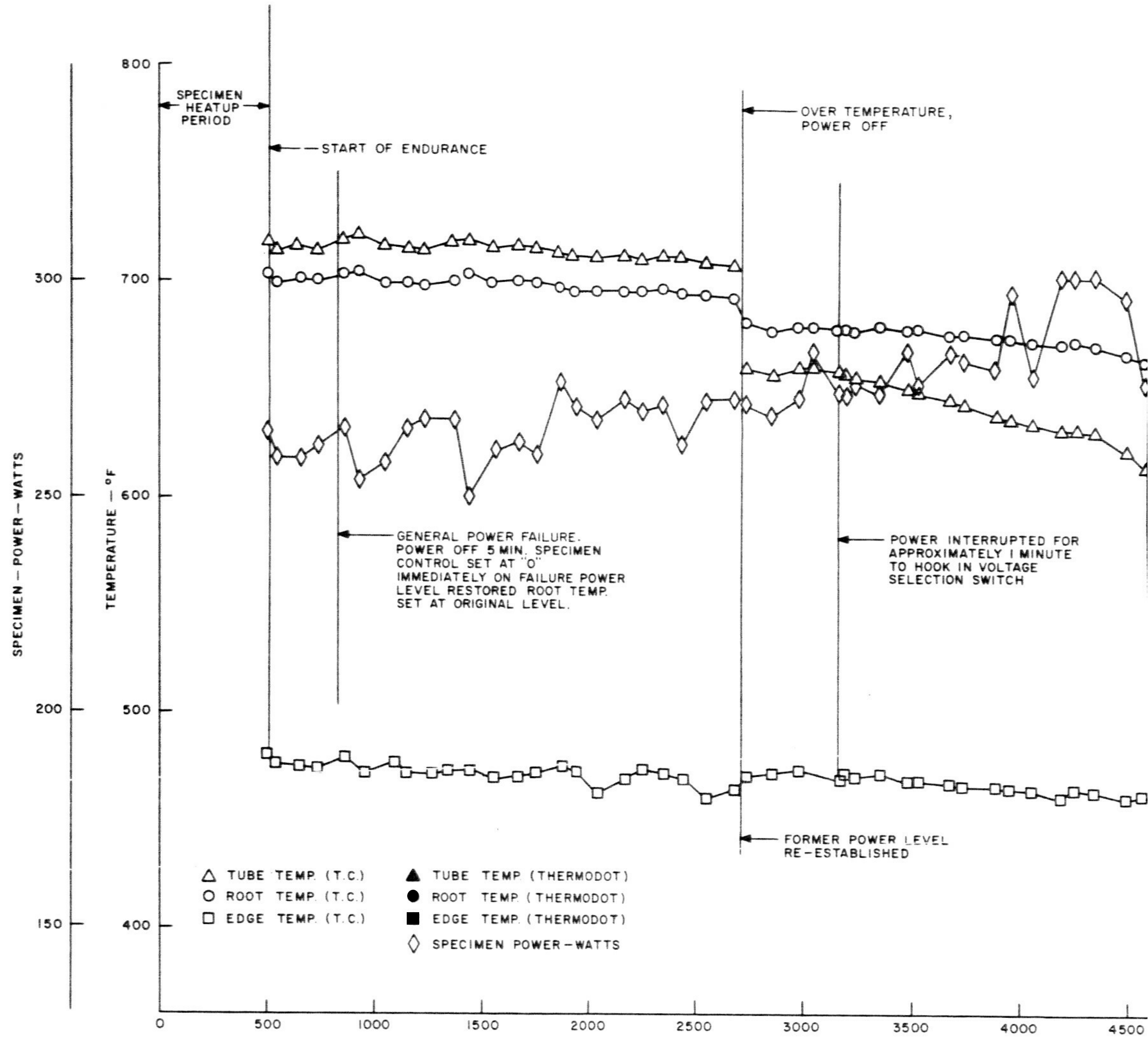

TOTAL HEMISPHERICAL EMITTANCE vs TIME
COATING: NICKEL CHROME SPINEL
SUBSTRATE: AISI-310 STAINLESS STEEL
FIRST ENDURANCE SPECIMEN
SINGLE DATA POINT
DAILY AVERAGE
SECOND ENDURANCE SPECIMEN
SINGLE DATA POINT
DAILY AVERAGE
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
ELAPSED TIME-HOURS
0
100
200
300
400
500
600

Figure 134

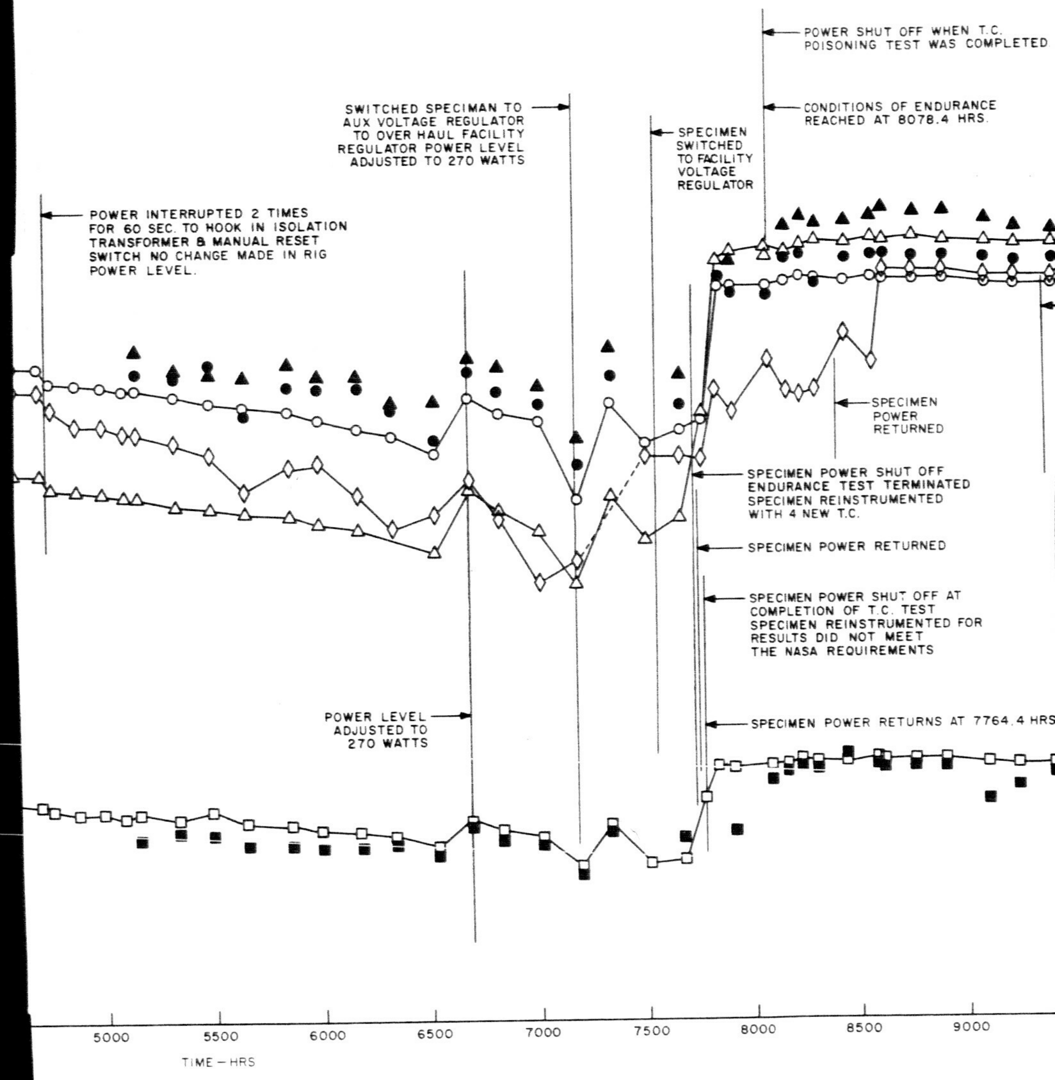
NICKEL CHROME



135

LONG TERM ENDURANCE TEST

SPINEL AND SILICA COATING ON SNAP-8 TEST SECTION



135 (2)

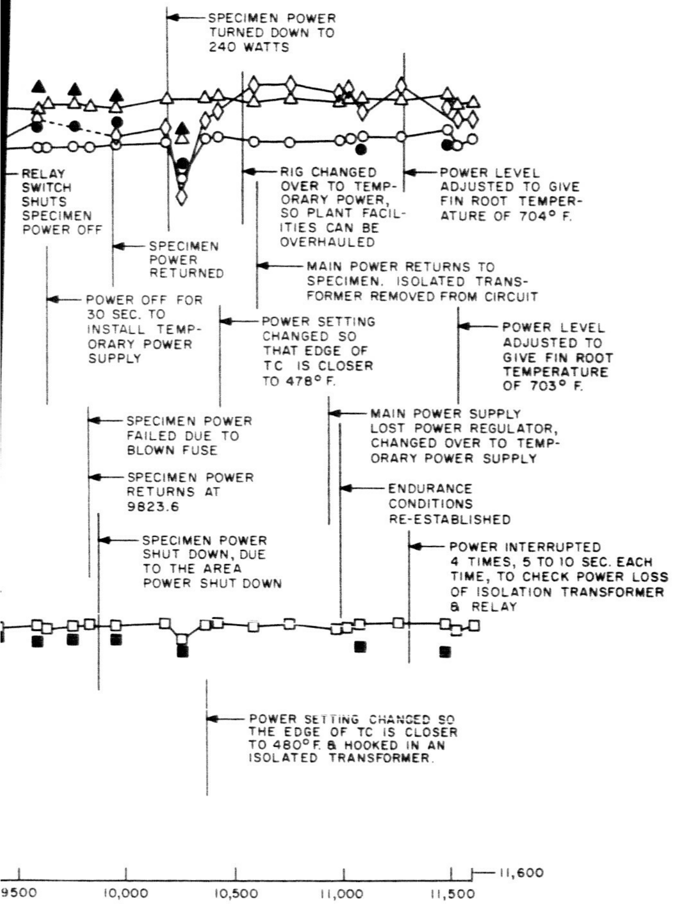
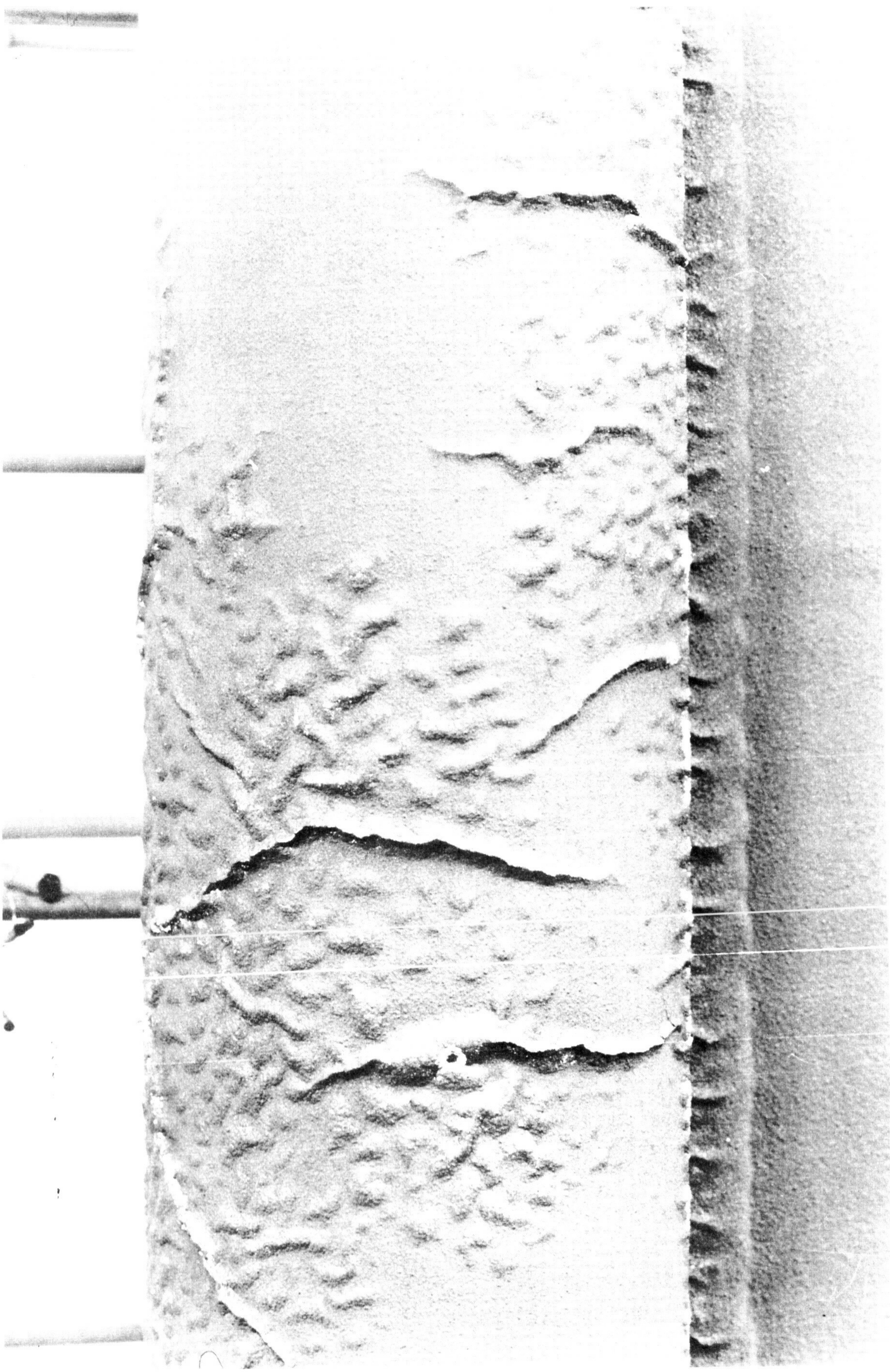

SPECIMEN POWER TURNED DOWN TO 240 WATTS
RELAY SWITCH SHUTS SPECIMEN POWER OFF
RIG CHANGED OVER TO TEMPORARY POWER, SO PLANT FACILITIES CAN BE OVERHAULED
POWER LEVEL ADJUSTED TO GIVE FIN ROOT TEMPERATURE OF 704° F.
SPECIMEN POWER RETURNED
MAIN POWER RETURNS TO SPECIMEN. ISOLATED TRANSFORMER REMOVED FROM CIRCUIT
POWER OFF FOR 30 SEC. TO INSTALL TEMPORARY POWER SUPPLY
POWER SETTING CHANGED SO THAT EDGE OF TC IS CLOSER TO 478° F.
POWER LEVEL ADJUSTED TO GIVE FIN ROOT TEMPERATURE OF 703° F.
SPECIMEN POWER FAILED DUE TO BLOWN FUSE
MAIN POWER SUPPLY LOST POWER REGULATOR, CHANGED OVER TO TEMPORARY POWER SUPPLY
SPECIMEN POWER RETURNS AT 9823.6
ENDURANCE CONDITIONS RE-ESTABLISHED
SPECIMEN POWER SHUT DOWN, DUE TO THE AREA POWER SHUT DOWN
POWER INTERRUPTED 4 TIMES, 5 TO 10 SEC. EACH TIME, TO CHECK POWER LOSS OF ISOLATION TRANSFORMER & RELAY
POWER SETTING CHANGED SO THE EDGE OF TC IS CLOSER TO 480° F. & HOOKED IN AN ISOLATED TRANSFORMER.
9500
10,000
10,500
11,000
11,500
11,600

Figure 135

3

NICKEL-CHROME SPINEL AND SILCON DIOXIDE COATED SNAP-8 TEST SECTION AFTER BEING OVERHEATED AFTER APPROXIMATELY 2700 HOURS OF ENDURANCE TESTING

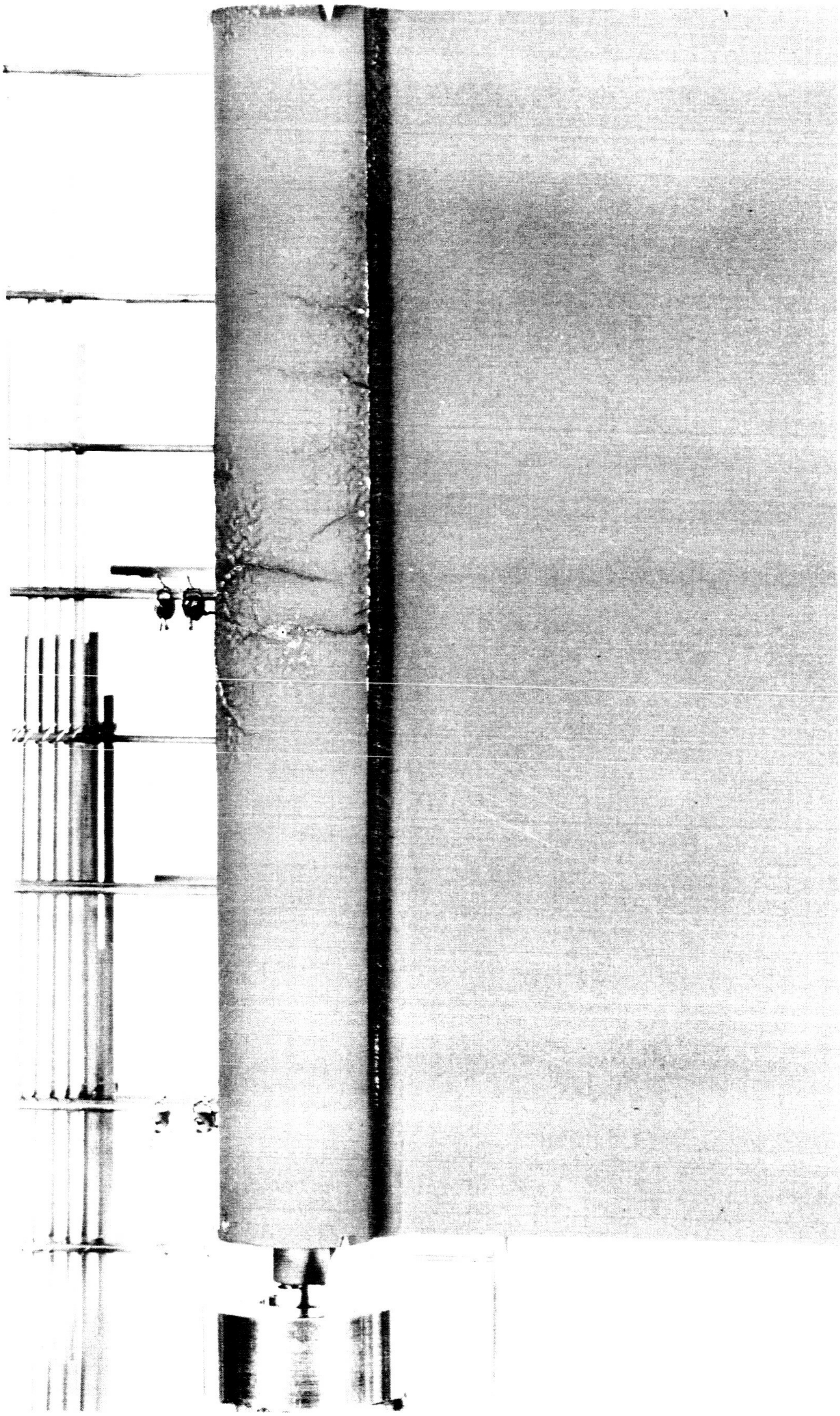
Figure 136



MAG: 3X

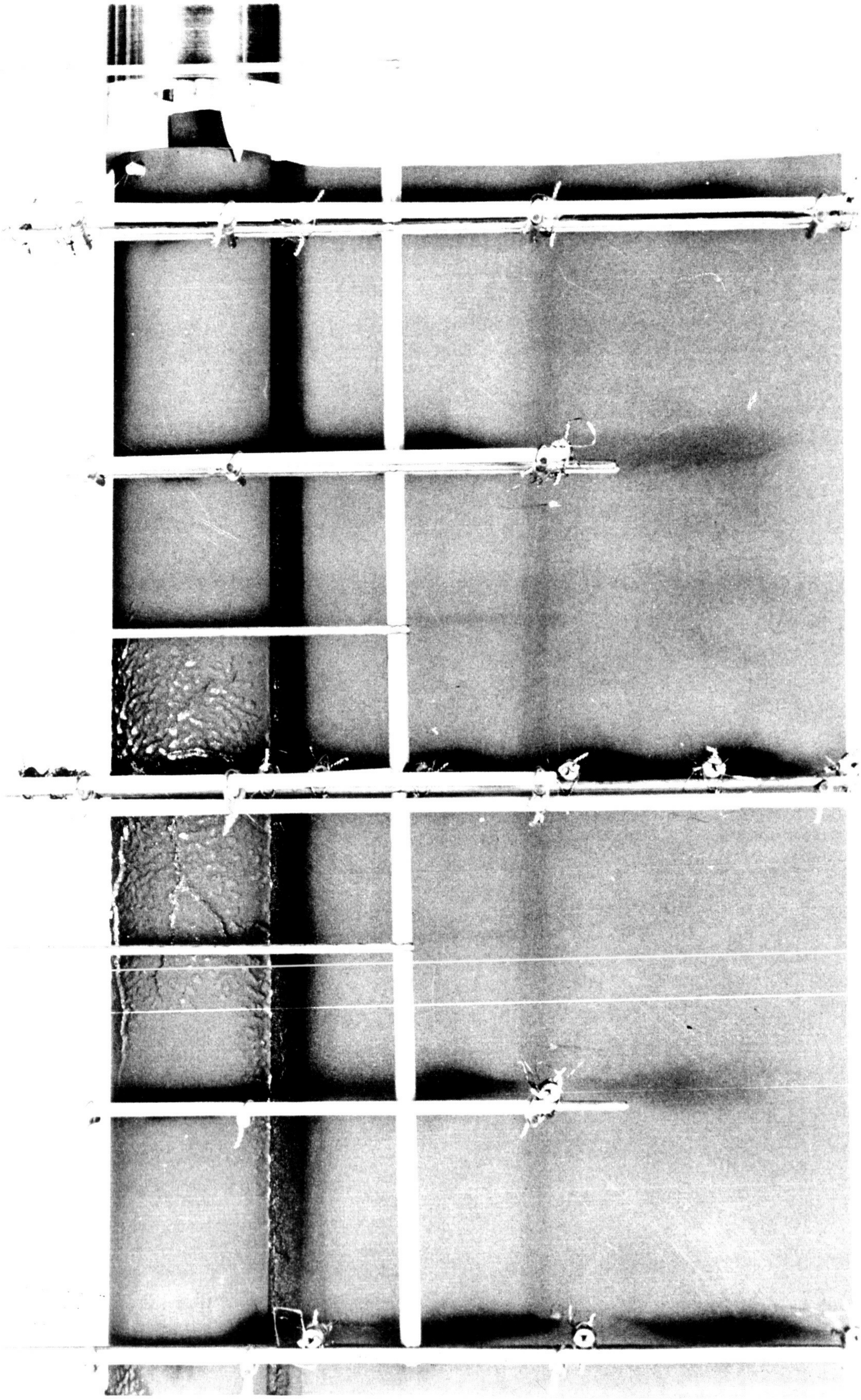
NICKEL-CHROME SPINEL AND SILCON DIOXIDE COATED SNAP-8 TEST SECTION AFTER 7200 HOURS OF ENDURANCE TESTING

Figure 137



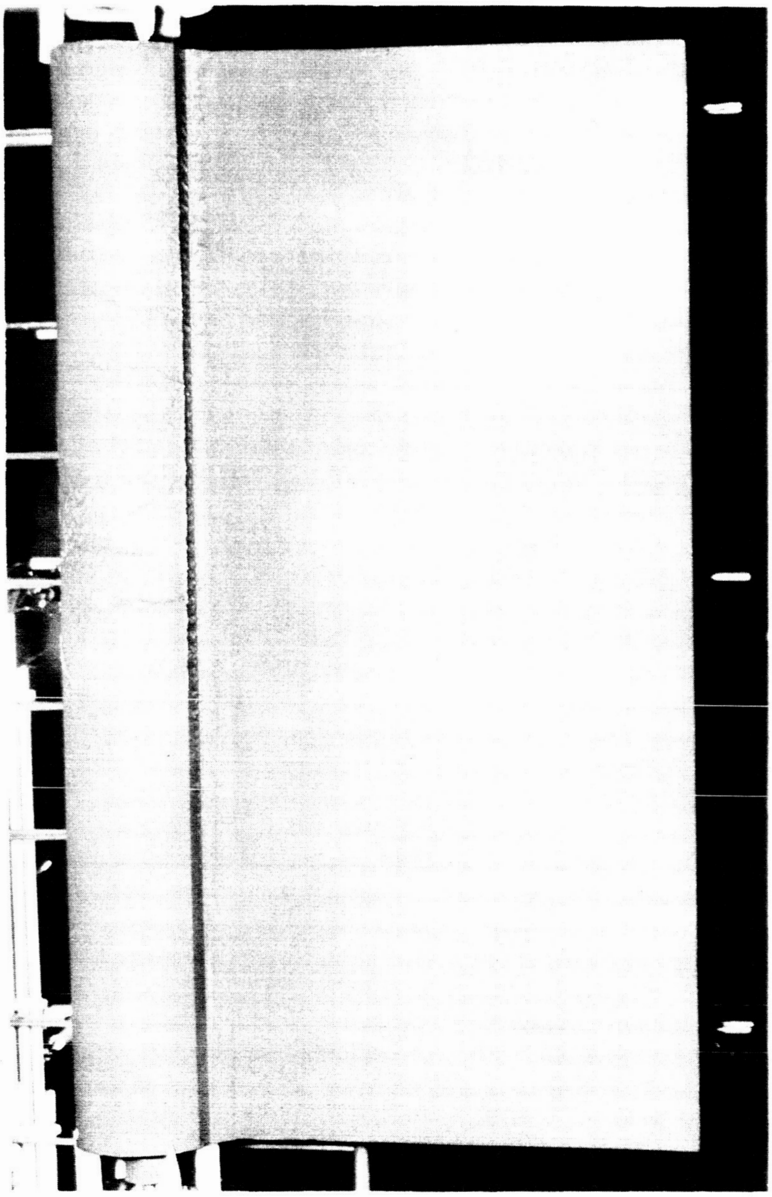
NICKEL-CHROME SPINEL AND SILCON DIOXIDE COATED SNAP-8
TEST SECTION AFTER 7200 HOURS OF ENDURANCE TESTING
(FRONT SIDE)

Figure 138



NICKEL-CHROME SPINEL AND SILICON DIOXIDE COATED SNAP-8 TEST SECTION AFTER 7200 HOURS OF ENDURANCE TESTING (BACK SIDE)

Figure 139



NICKEL-CHROME SPINEL AND SILCON DIOXIDE COATED SNAP-8 TEST SECTION AFTER APPROXIMATELY 10,800 HOURS OF ENDURANCE TESTING

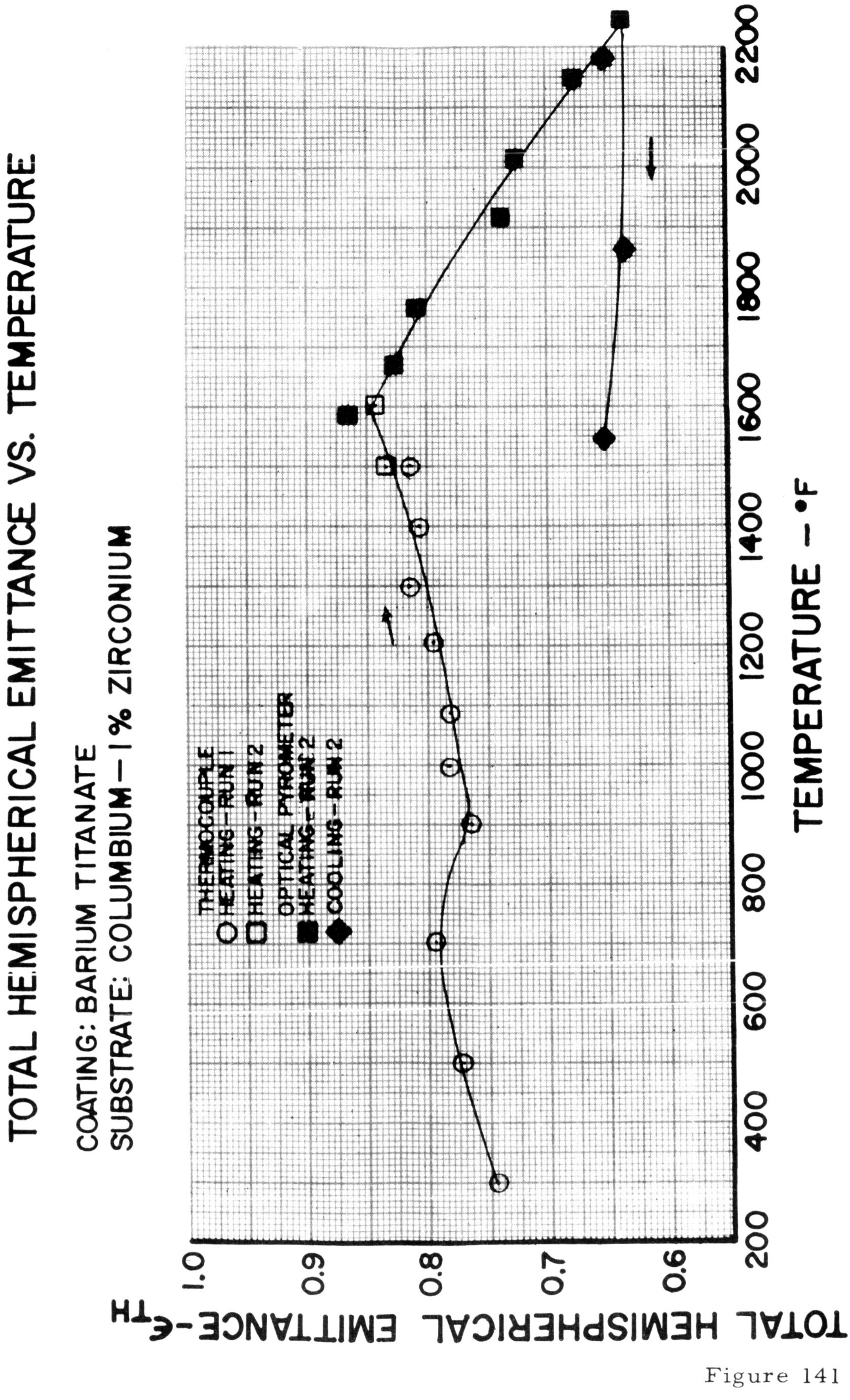

TOTAL HEMISPHERICAL EMITTANCE VS. TEMPERATURE
COATING: BARIUM TITANATE
SUBSTRATE: COLUMBIUM—1% ZIRCONIUM
THERMOCOUPLE
HEATING—RUN 1
HEATING—RUN 2
OPTICAL PYROMETER
HEATING—RUN 2
COOLING—RUN 2
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 141

SPECTRAL NORMAL EMITTANCE VS WAVELENGTH

COATING: BARIUM TITANATE
SUBSTRATE: COLUMBIUM-1% ZIRCONIUM

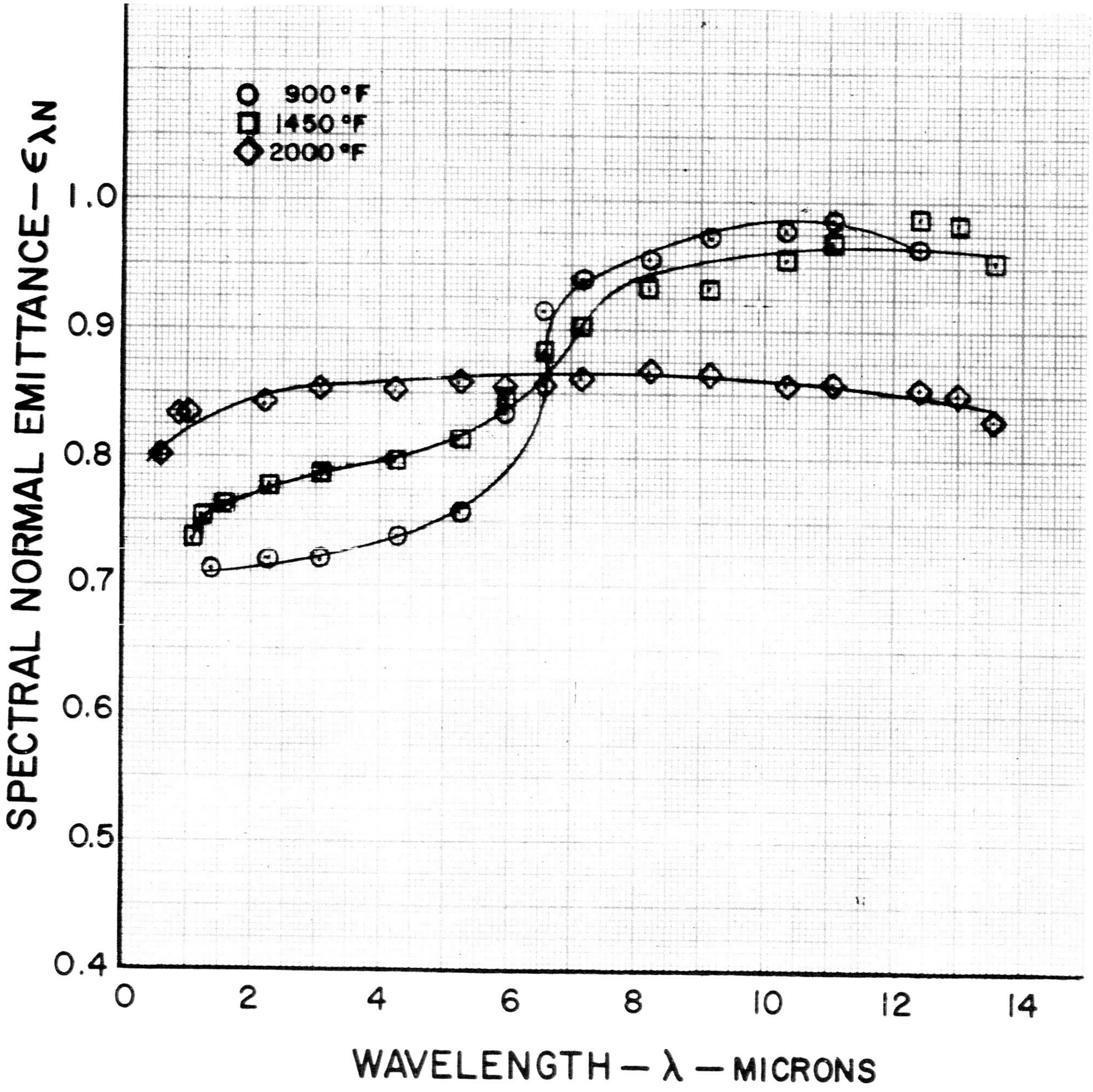


Figure 142

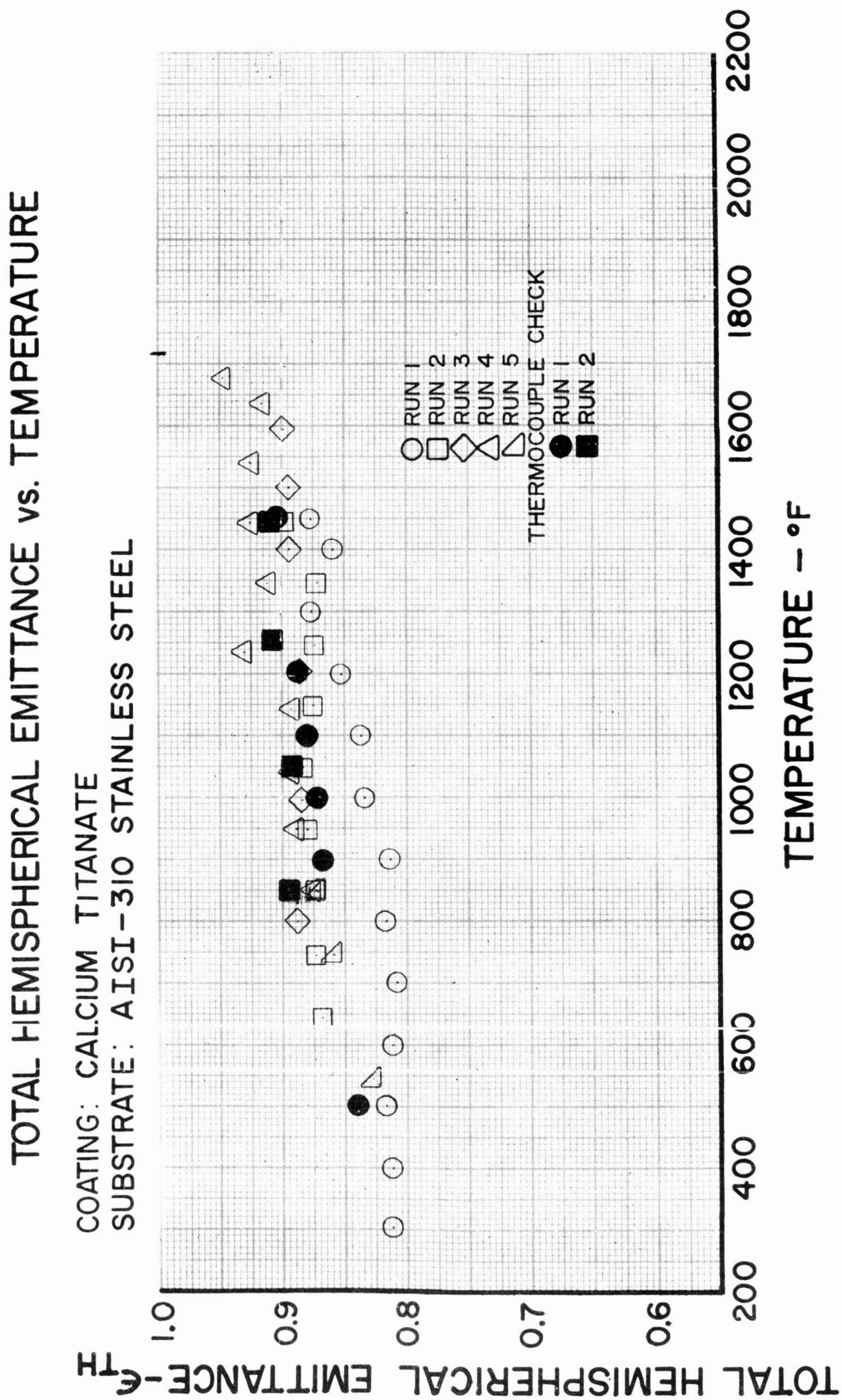

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: CALCIUM TITANATE
SUBSTRATE: AISI-310 STAINLESS STEEL
RUN 1
RUN 2
RUN 3
RUN 4
RUN 5
THERMOCOUPLE CHECK
RUN 1
RUN 2
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 143 a

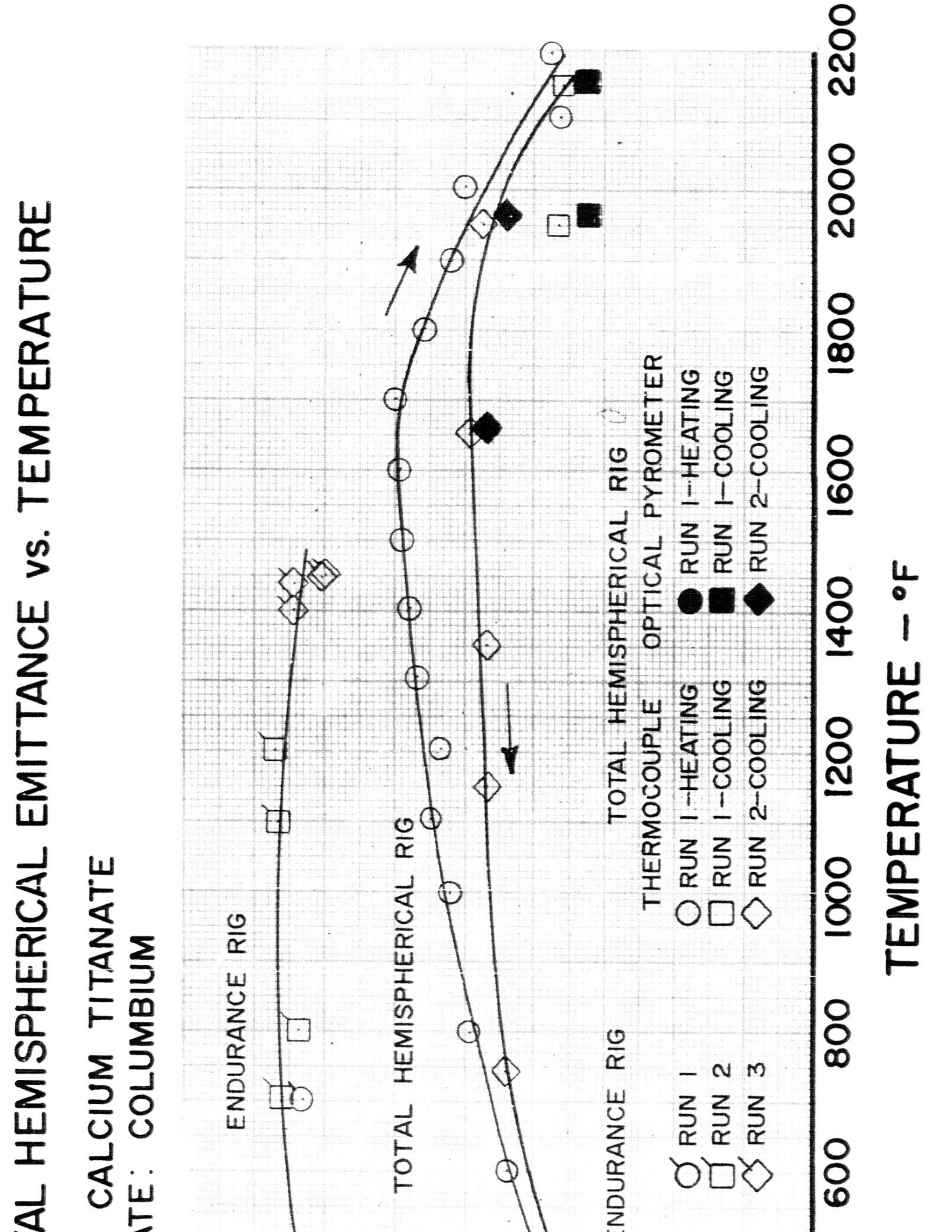

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: CALCIUM TITANATE
SUBSTRATE: COLUMBIUM
ENDURANCE RIG
TOTAL HEMISPHERICAL RIG
ENDURANCE RIG
RUN 1
RUN 2
RUN 3
TOTAL HEMISPHERICAL RIG
THERMOCOUPLE
RUN 1-HEATING
RUN 1-COOLING
RUN 2-COOLING
OPTICAL PYROMETER
RUN 1-HEATING
RUN 1-COOLING
RUN 2-COOLING
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
TEMPERATURE — °F
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200

Figure 143b

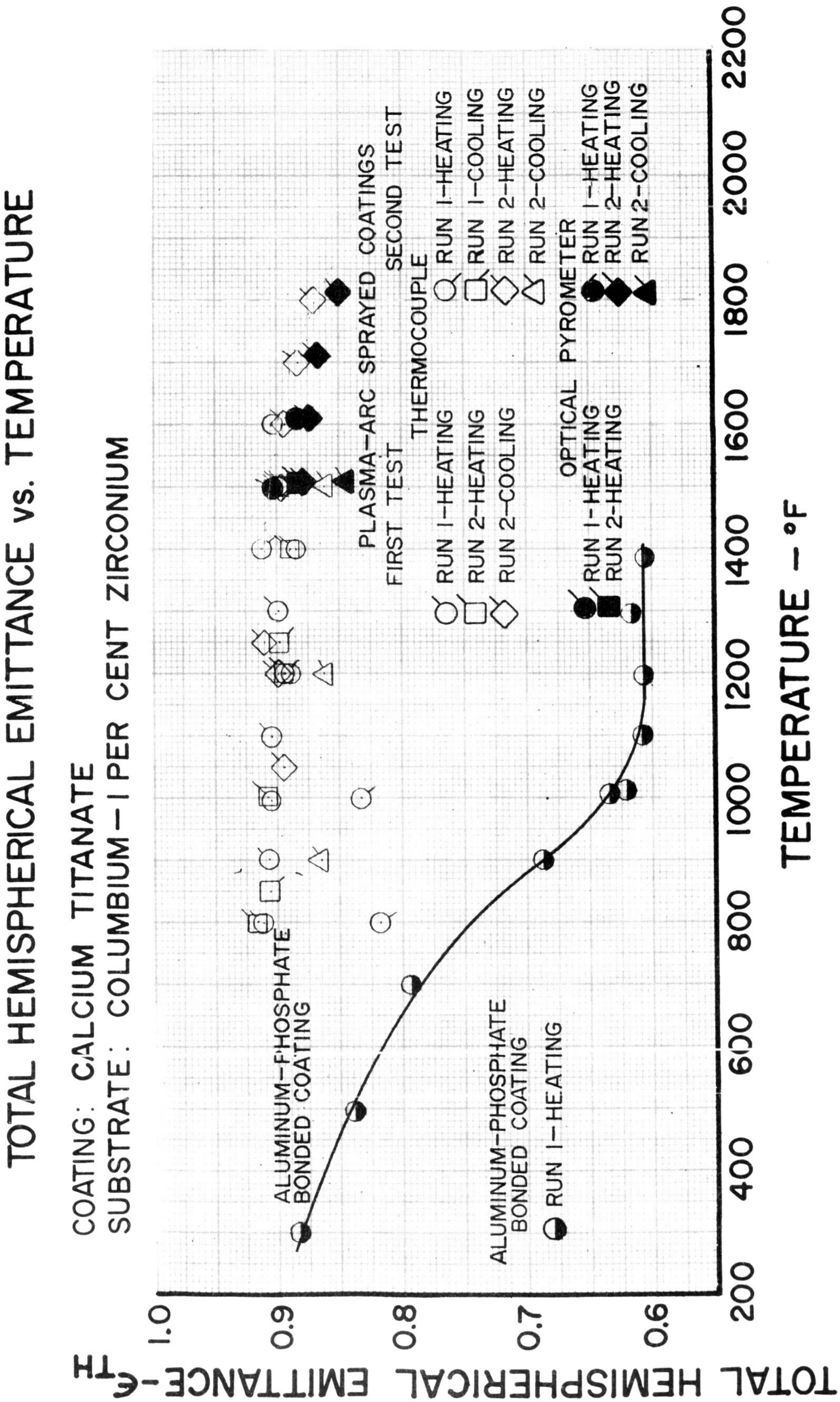

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: CALCIUM TITANATE
SUBSTRATE: COLUMBIUM-1 PER CENT ZIRCONIUM
ALUMINUM-PHOSPHATE BONDED COATING
ALUMINUM-PHOSPHATE BONDED COATING
RUN 1-HEATING
PLASMA-ARC SPRAYED COATINGS
FIRST TEST
SECOND TEST
THERMOCOUPLE
RUN 1-HEATING
RUN 2-HEATING
RUN 2-COOLING
RUN 1-HEATING
RUN 1-COOLING
RUN 2-HEATING
RUN 2-COOLING
OPTICAL PYROMETER
RUN 1-HEATING
RUN 2-HEATING
RUN 1-HEATING
RUN 2-HEATING
RUN 2-COOLING
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 143 c

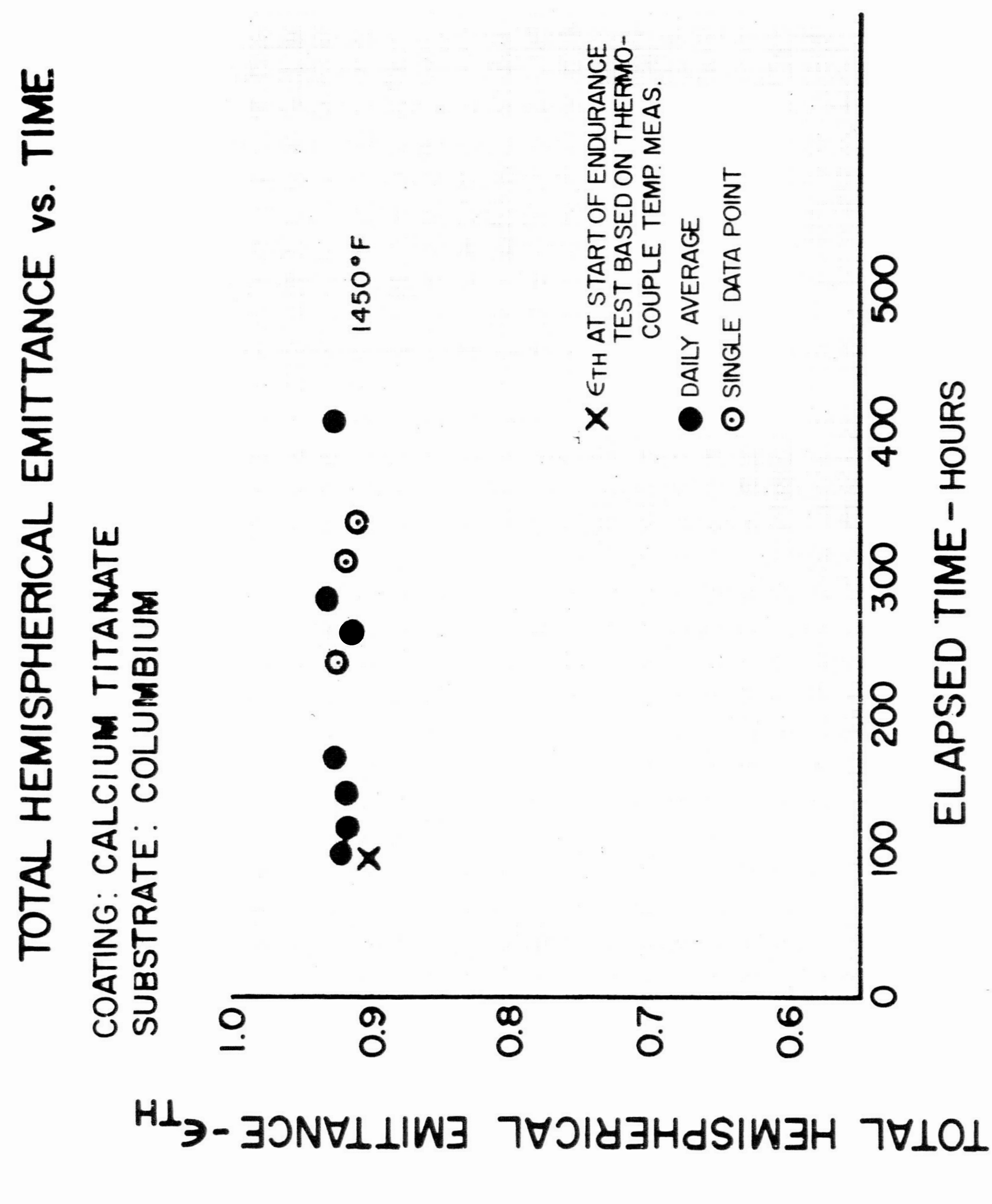

TOTAL HEMISPHERICAL EMITTANCE vs. TIME
COATING: CALCIUM TITANATE
SUBSTRATE: COLUMBIUM
1450°F
X ϵ_{TH} AT START OF ENDURANCE TEST BASED ON THERMO-COUPLE TEMP. MEAS.
DAILY AVERAGE
SINGLE DATA POINT
TOTAL HEMISPHERICAL EMITTANCE - ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
0
100
200
300
400
500
ELAPSED TIME - HOURS

Figure 144

SPECTRAL NORMAL EMITTANCE vs. WAVELENGTH

COATING: CALCIUM TITANATE
SUBSTRATE: COLUMBIUM, COLUMBIUM-1% ZIRCONIUM

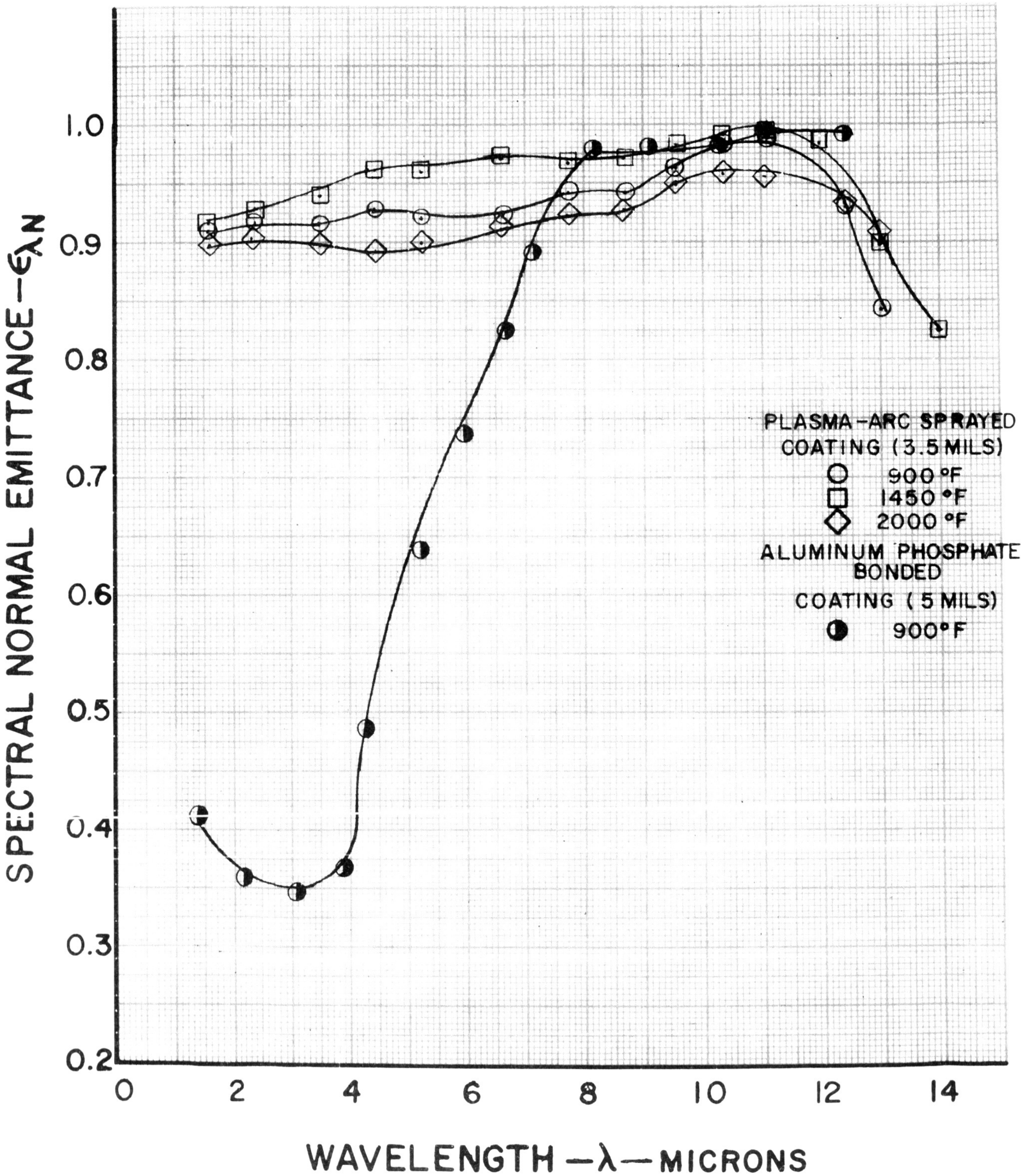
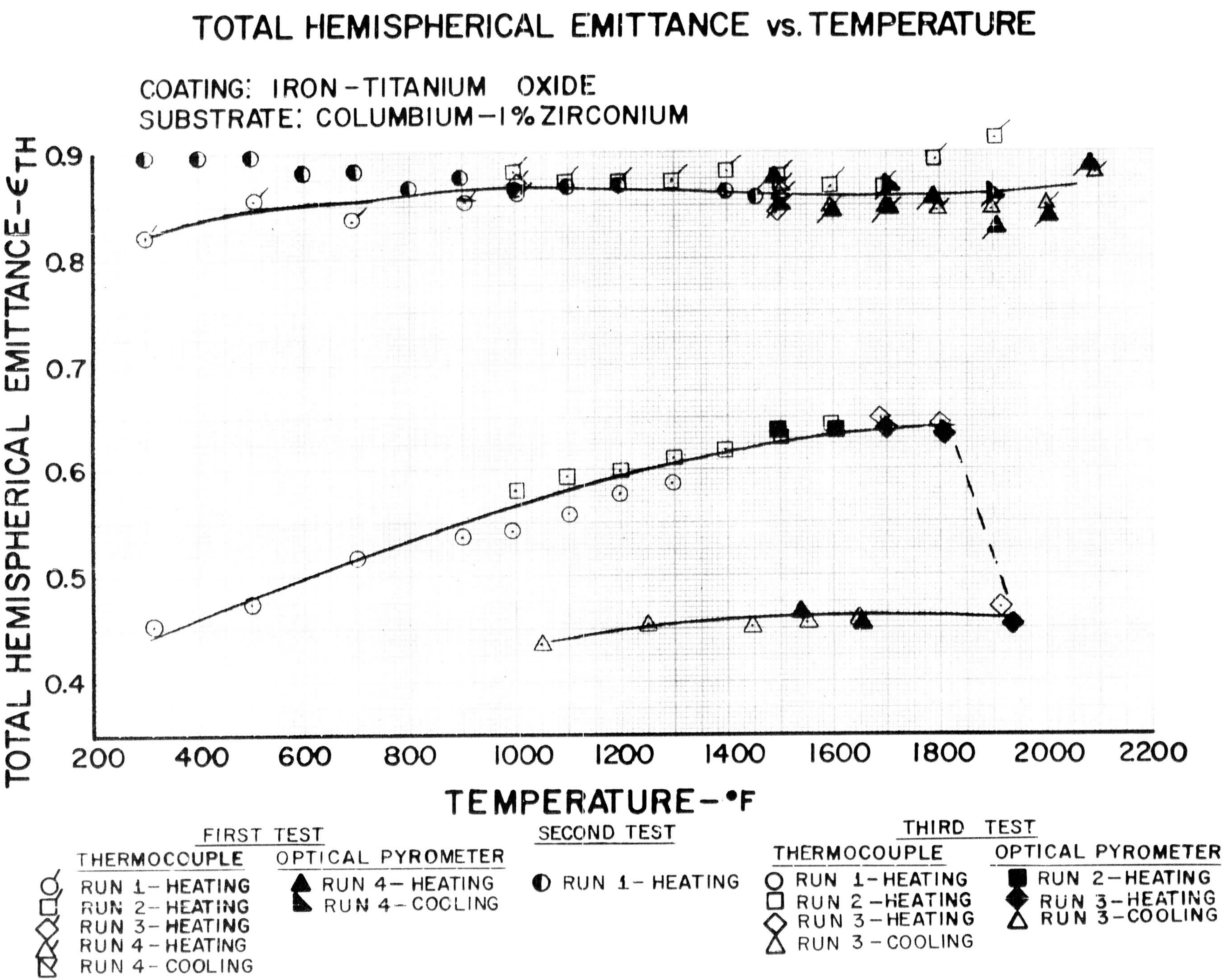


Figure 145


TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: IRON-TITANIUM OXIDE
SUBSTRATE: COLUMBIUM-1% ZIRCONIUM
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
0.9
0.8
0.7
0.6
0.5
0.4
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE-°F
FIRST TEST
THERMOCOUPLE
RUN 1-HEATING
RUN 2-HEATING
RUN 3-HEATING
RUN 4-HEATING
RUN 4-COOLING
OPTICAL PYROMETER
RUN 4-HEATING
RUN 4-COOLING
SECOND TEST
RUN 1-HEATING
THIRD TEST
THERMOCOUPLE
RUN 1-HEATING
RUN 2-HEATING
RUN 3-HEATING
RUN 3-COOLING
OPTICAL PYROMETER
RUN 2-HEATING
RUN 3-HEATING
RUN 3-COOLING

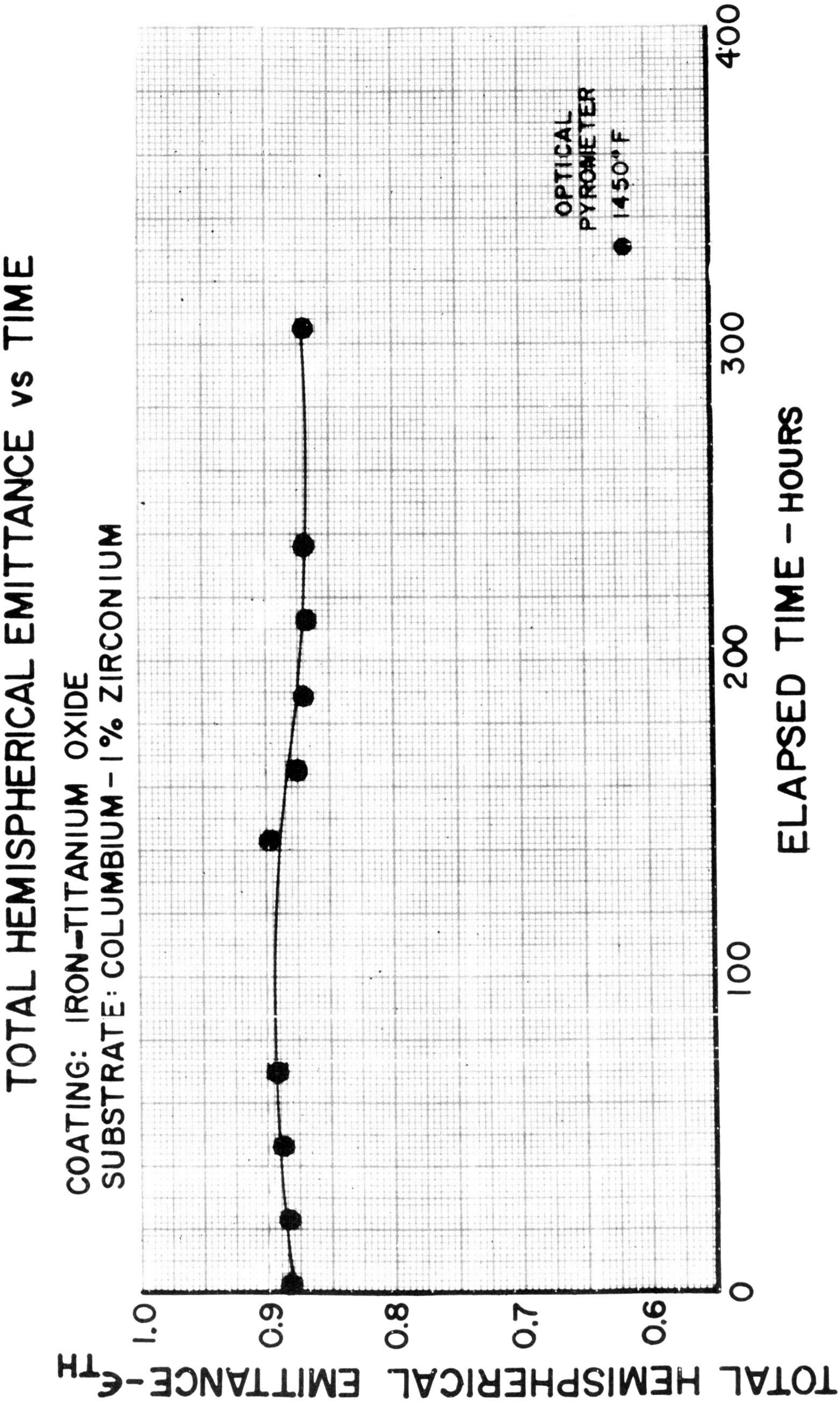

TOTAL HEMISPHERICAL EMITTANCE vs TIME
COATING: IRON-TITANIUM OXIDE
SUBSTRATE: COLUMBIUM-1% ZIRCONIUM
OPTICAL PYROMETER
1450°F
ELAPSED TIME - HOURS
0
100
200
300
400
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6

Figure 147

SPECTRAL NORMAL EMITTANCE vs. WAVELENGTH

COATING: IRON-TITANIUM OXIDE
SUBSTRATE: COLUMBIUM – 1% ZIRCONIUM

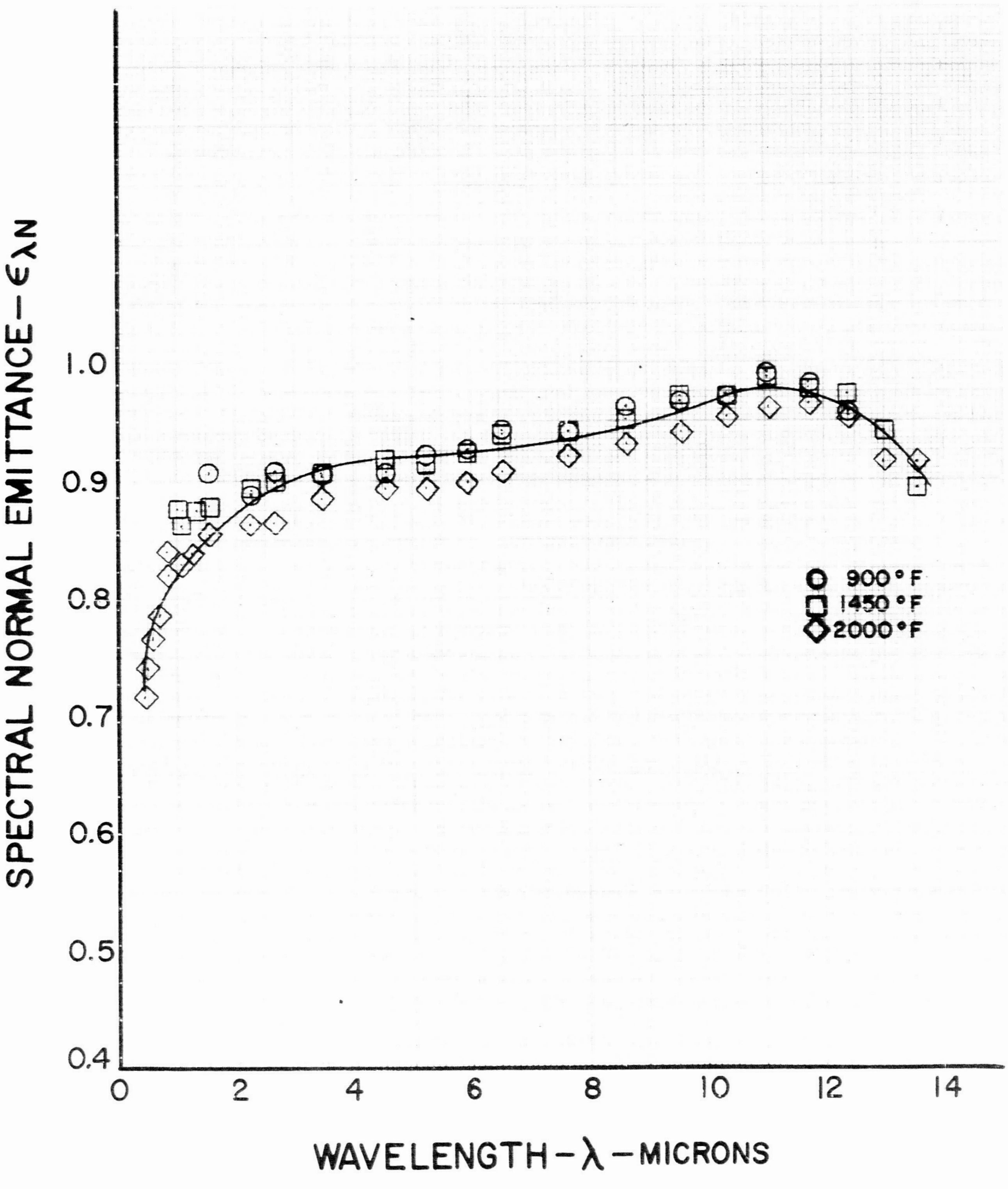


Figure 148

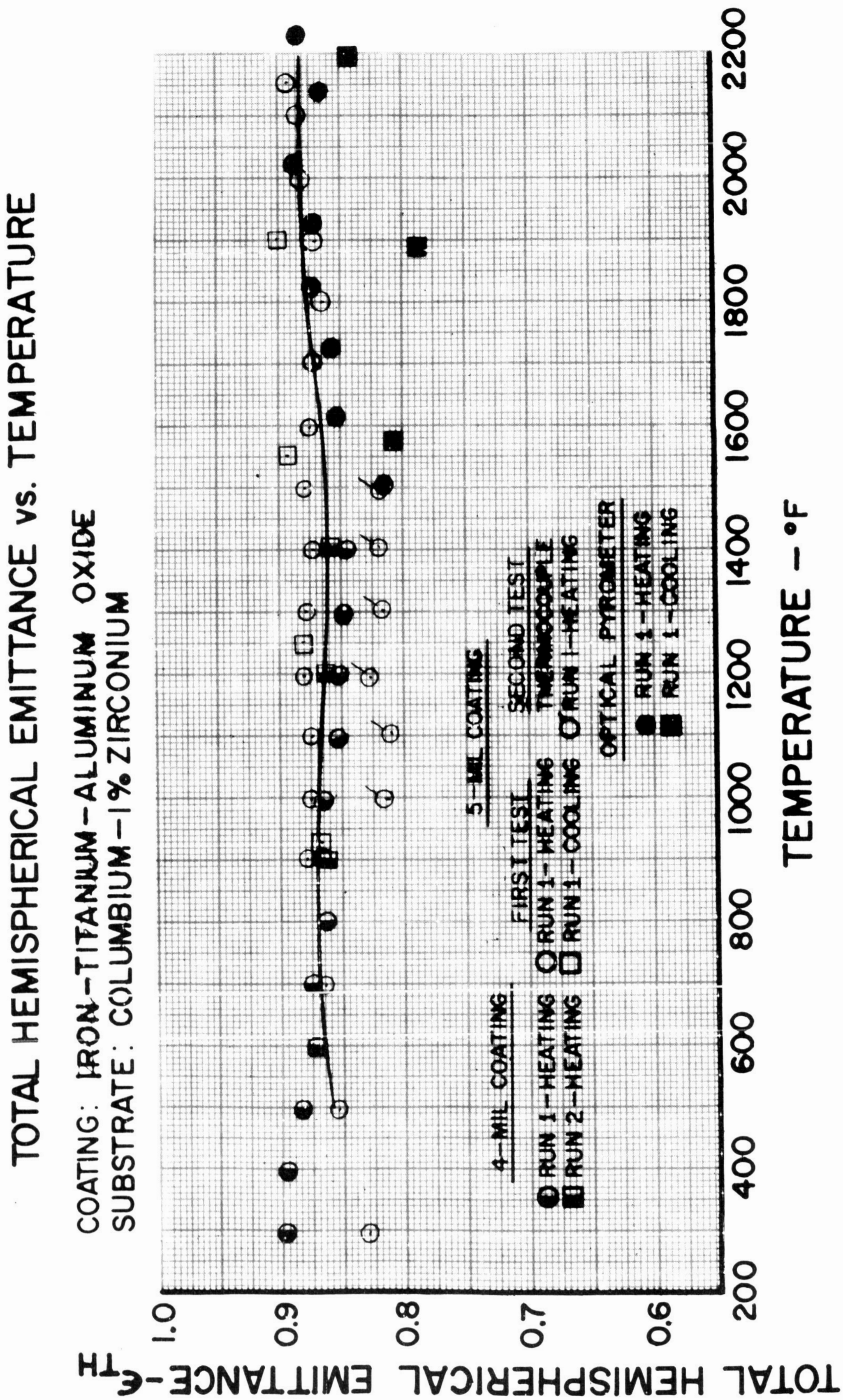

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: IRON-TITANIUM-ALUMINUM OXIDE
SUBSTRATE: COLUMBIUM-1% ZIRCONIUM
4-MIL COATING
RUN 1-HEATING
RUN 2-HEATING
5-MIL COATING
FIRST TEST
RUN 1-HEATING
RUN 1-COOLING
SECOND TEST
THERMOCOUPLE
RUN 1-HEATING
OPTICAL PYROMETER
RUN 1-HEATING
RUN 1-COOLING
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F
1.0
0.9
0.8
0.7
0.6
TOTAL HEMISPHERICAL EMITTANCE-ε TH

Figure 149

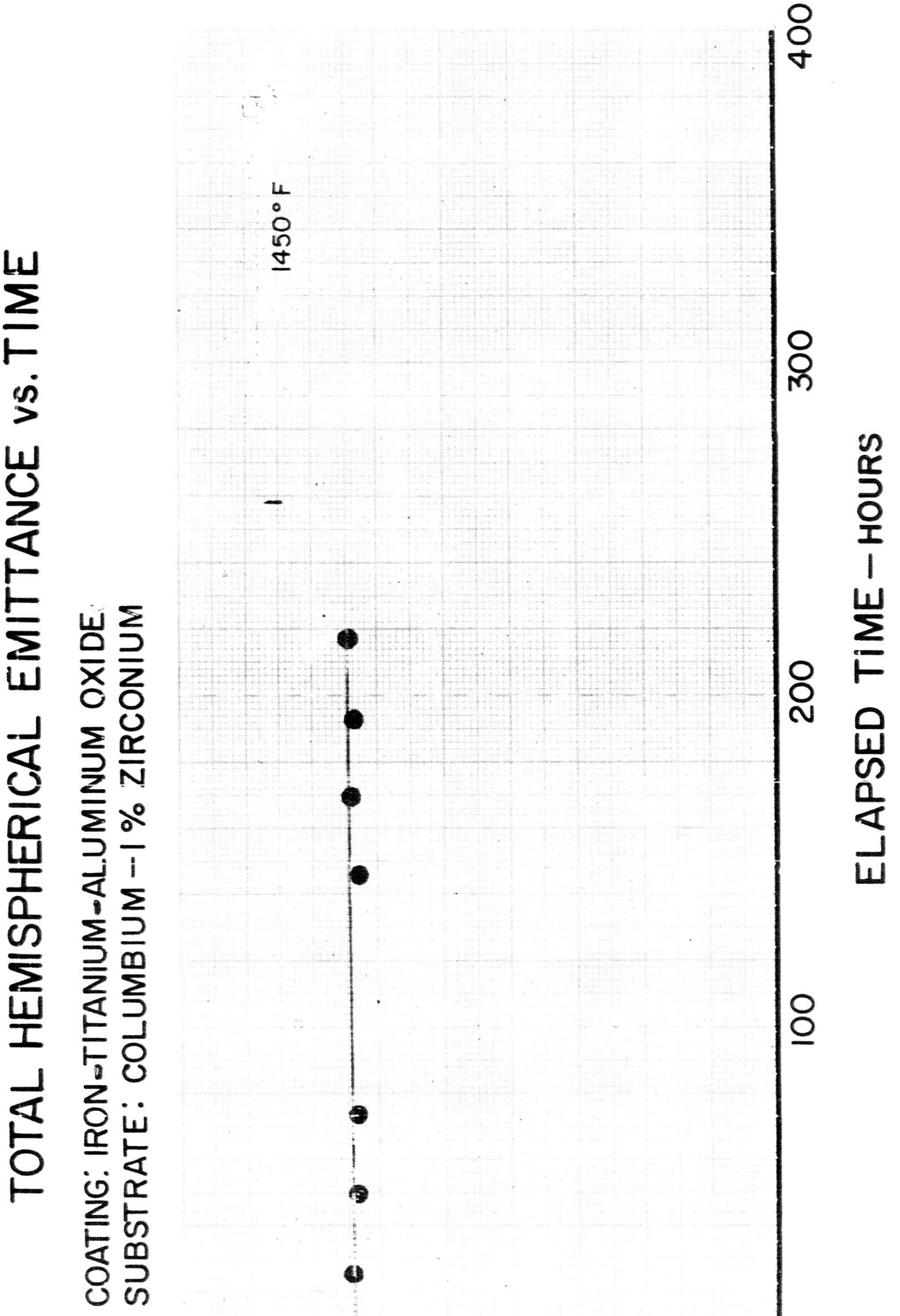

TOTAL HEMISPHERICAL EMITTANCE vs. TIME
COATING: IRON-TITANIUM-ALUMINUM OXIDE
SUBSTRATE: COLUMBIUM --1% ZIRCONIUM
1450°F
ELAPSED TIME — HOURS
0
100
200
300
400
TOTAL HEMISPHERICAL EMITTANCE -ϵ_{TH}
1.0
0.9
0.8
0.7
0.6

Figure 150

SPECTRAL NORMAL EMITTANCE vs. WAVELENGTH

COATING: IRON-TITANIUM-ALUMINUM OXIDE
SUBSTRATE: COLUMBIUM-1% ZIRCONIUM

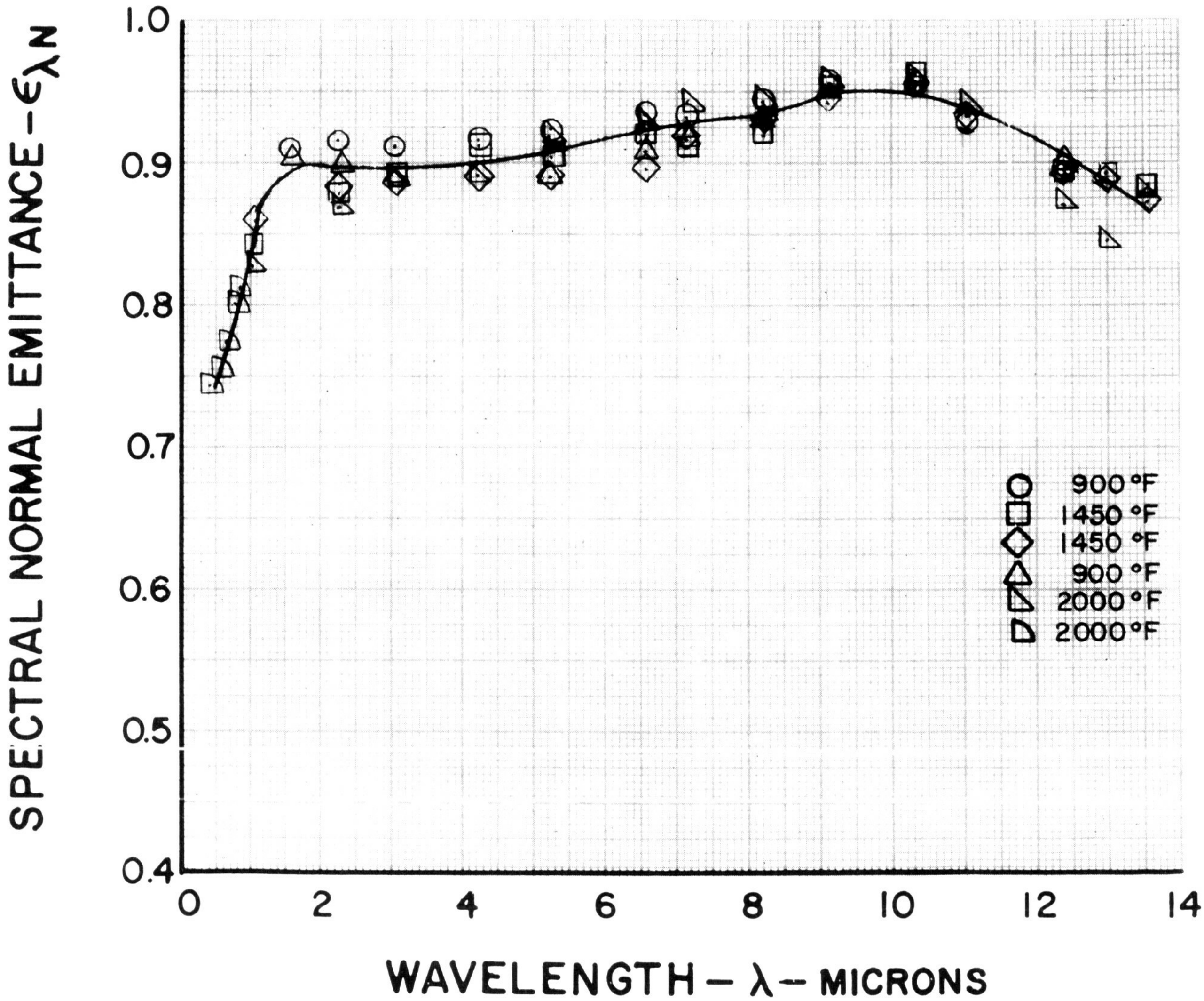


Figure 151

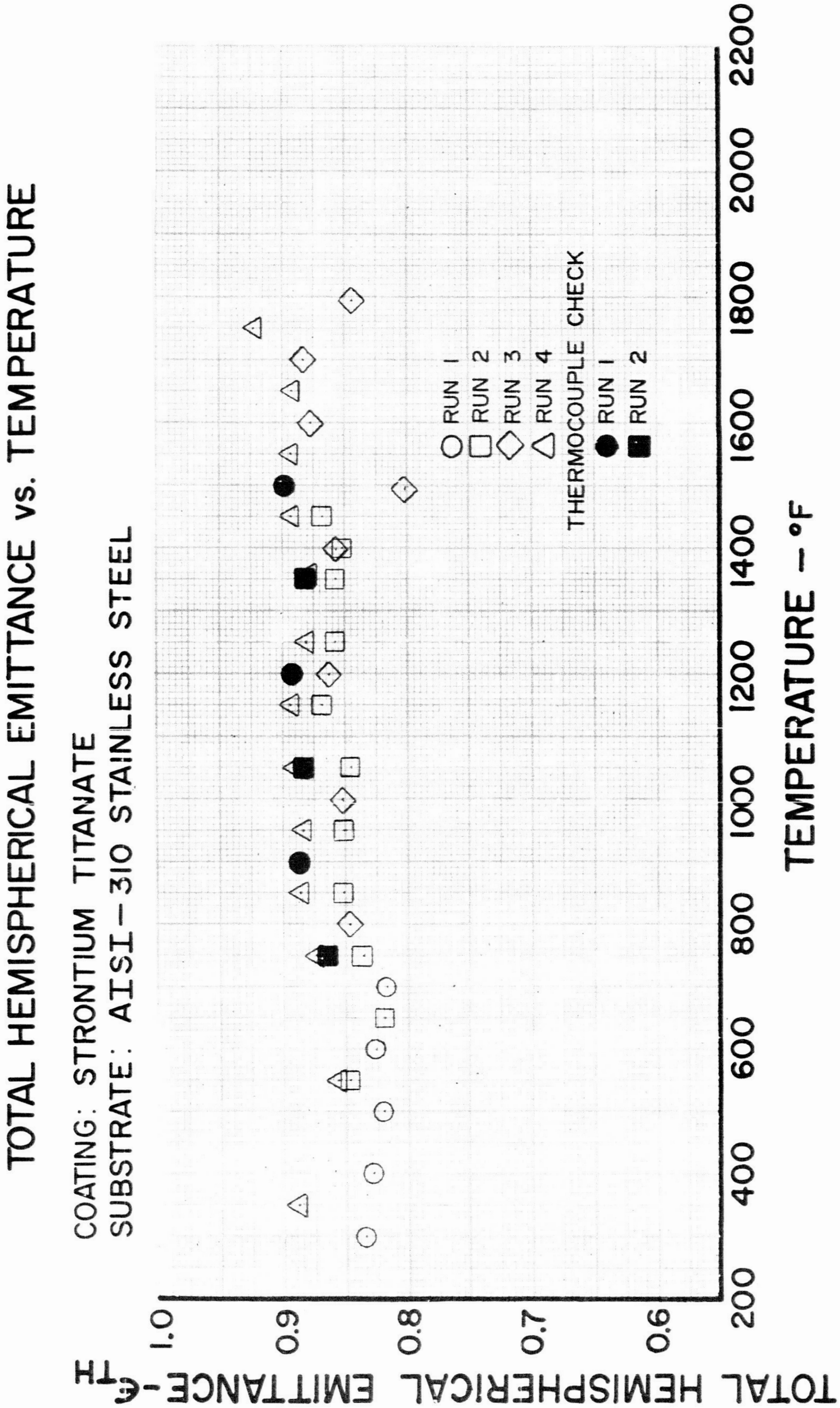
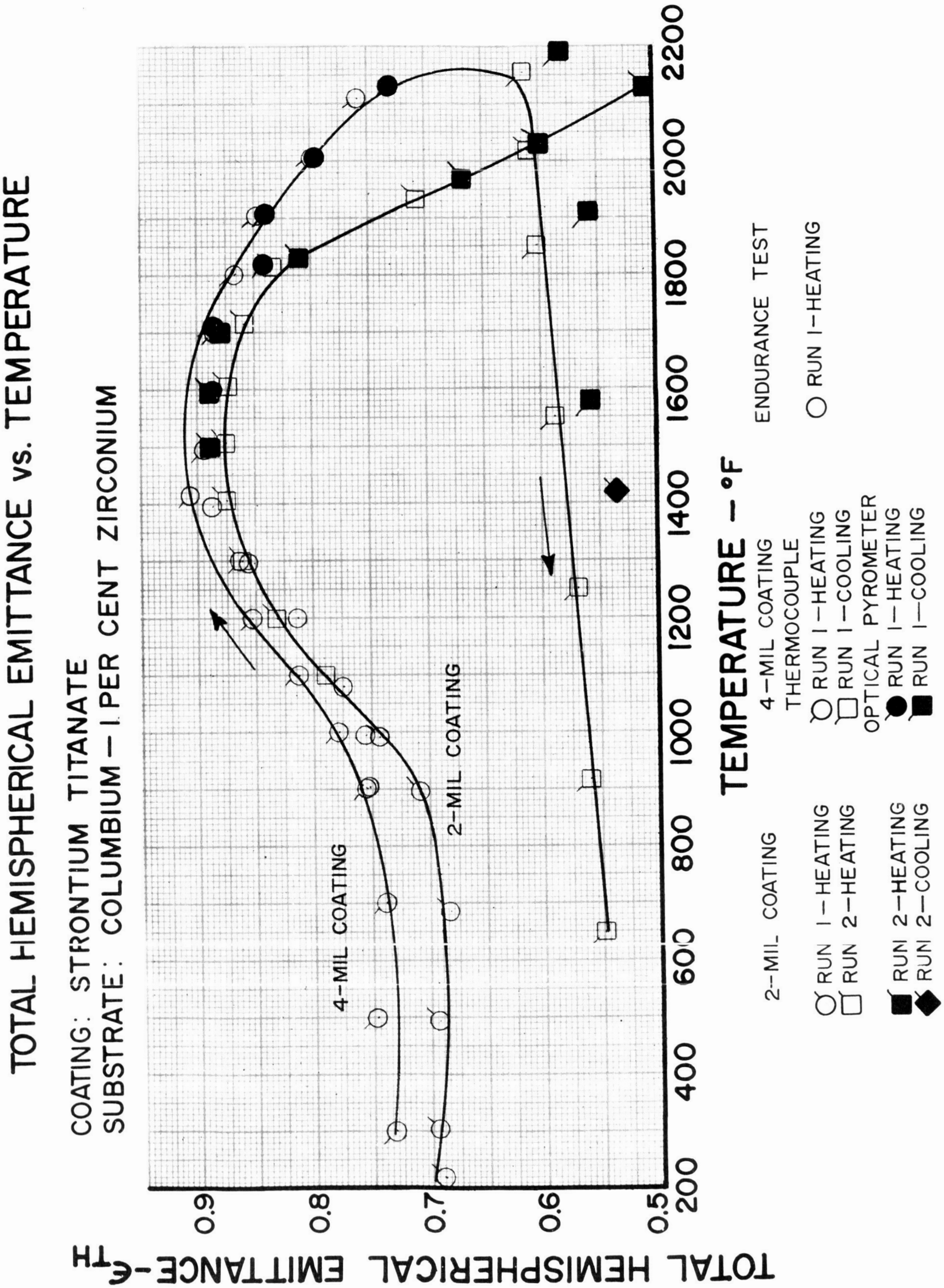

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: STRONTIUM TITANATE
SUBSTRATE: AISI-310 STAINLESS STEEL
RUN 1
RUN 2
RUN 3
RUN 4
THERMOCOUPLE CHECK
RUN 1
RUN 2
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 152 a



TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: STRONTIUM TITANATE
SUBSTRATE: COLUMBIUM – 1 PER CENT ZIRCONIUM
TOTAL HEMISPHERICAL EMITTANCE – ϵ_{TH}
0.9
0.8
0.7
0.6
0.5
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE – °F
4-MIL COATING
2-MIL COATING
2-MIL COATING
RUN 1–HEATING
RUN 2–HEATING
RUN 2–HEATING
RUN 2–COOLING
4-MIL COATING
THERMOCOUPLE
RUN 1–HEATING
RUN 1–COOLING
OPTICAL PYROMETER
RUN 1–HEATING
RUN 1–COOLING
ENDURANCE TEST
RUN 1–HEATING

Figure 152 b

SPECTRAL NORMAL EMITTANCE vs WAVELENGTH

COATING: STRONTIUM TITANATE--PLASMA ARC SPRAYED (4 MILS)
SUBSTRATE: COLUMBIUM-1% ZIRCONIUM

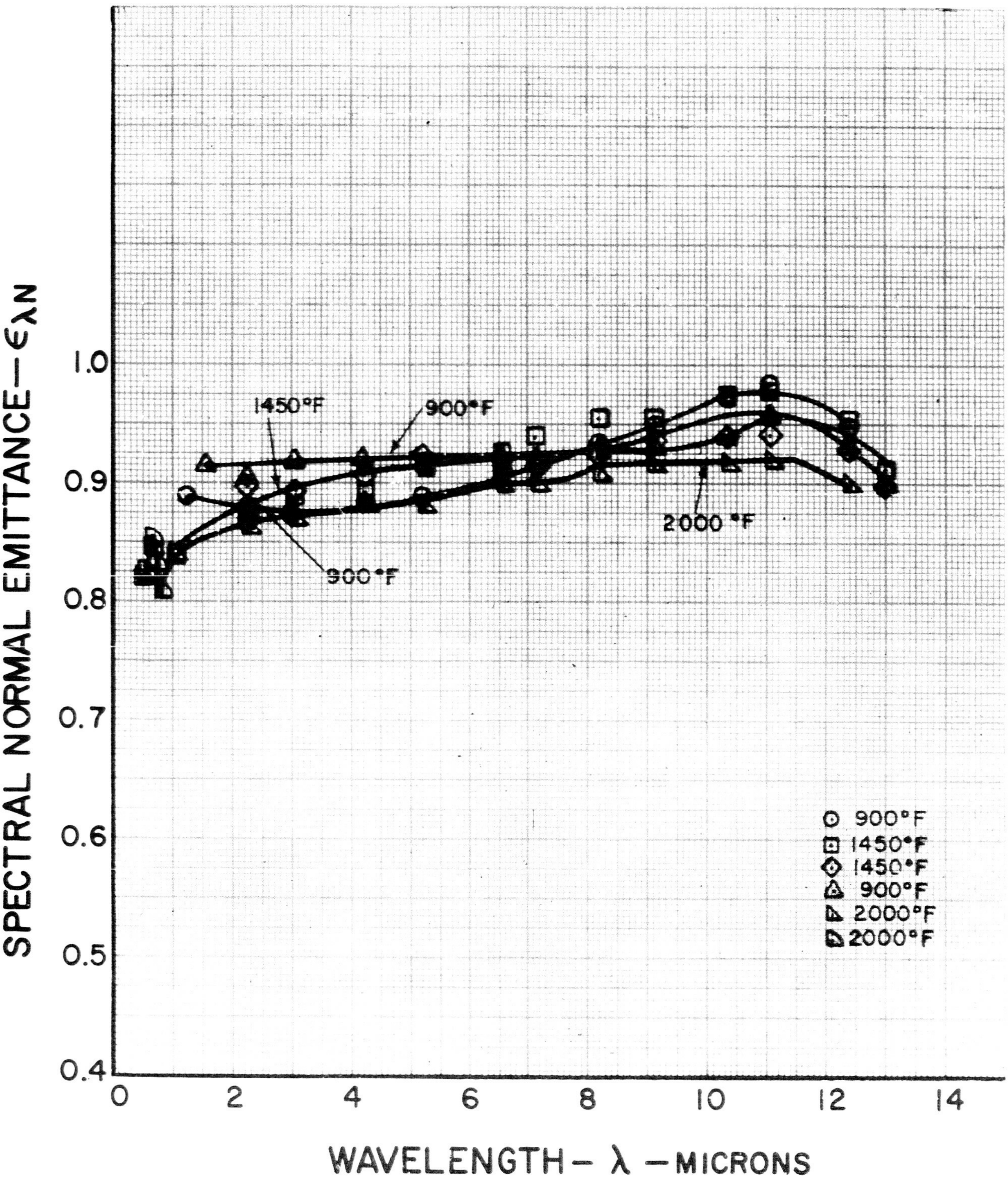


Figure 153

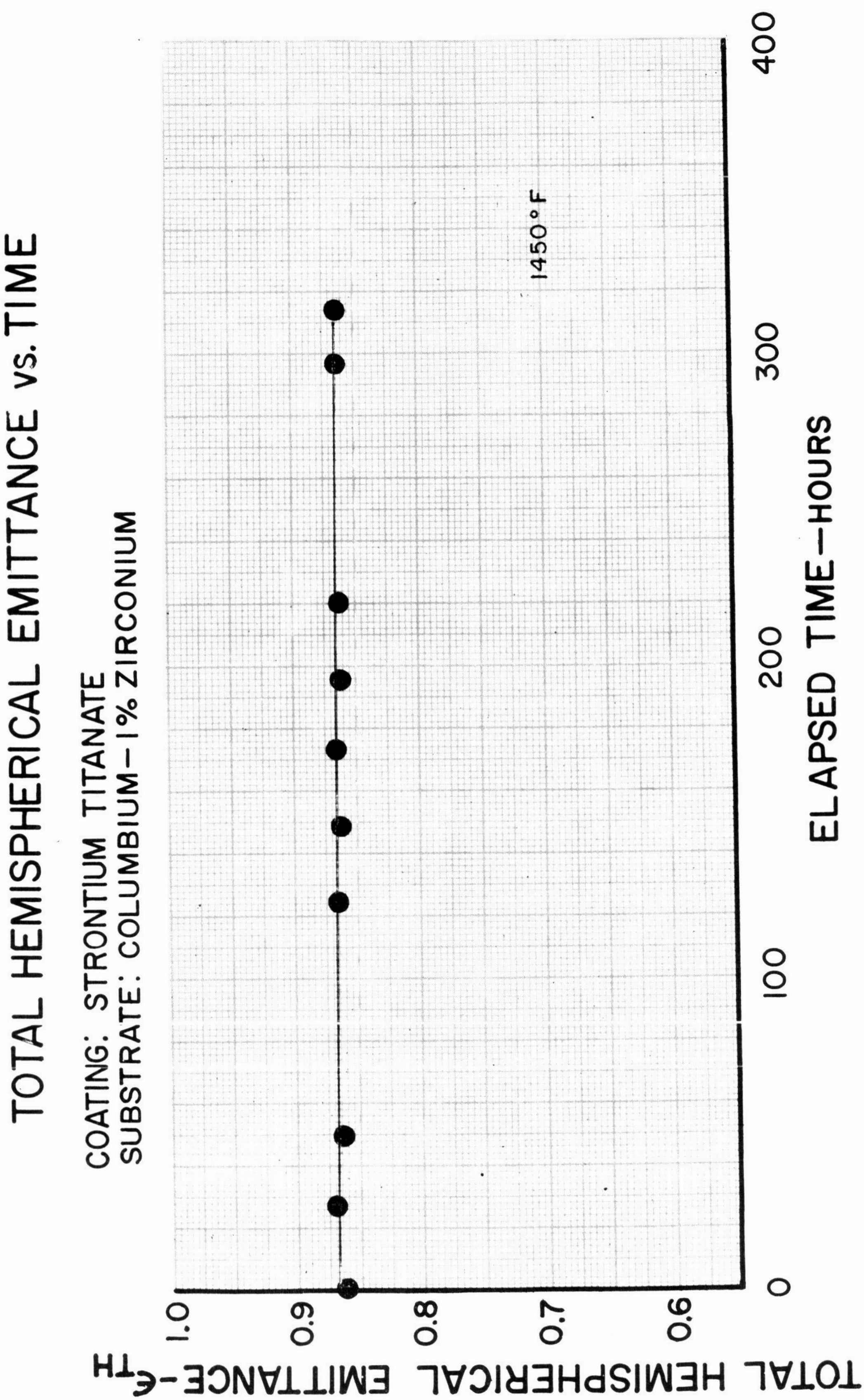

TOTAL HEMISPHERICAL EMITTANCE vs. TIME
COATING: STRONTIUM TITANATE
SUBSTRATE: COLUMBIUM- 1% ZIRCONIUM
1450°F
ELAPSED TIME—HOURS
0
100
200
300
400
TOTAL HEMISPHERICAL EMITTANCE-ϵTH
1.0
0.9
0.8
0.7
0.6

Figure 154

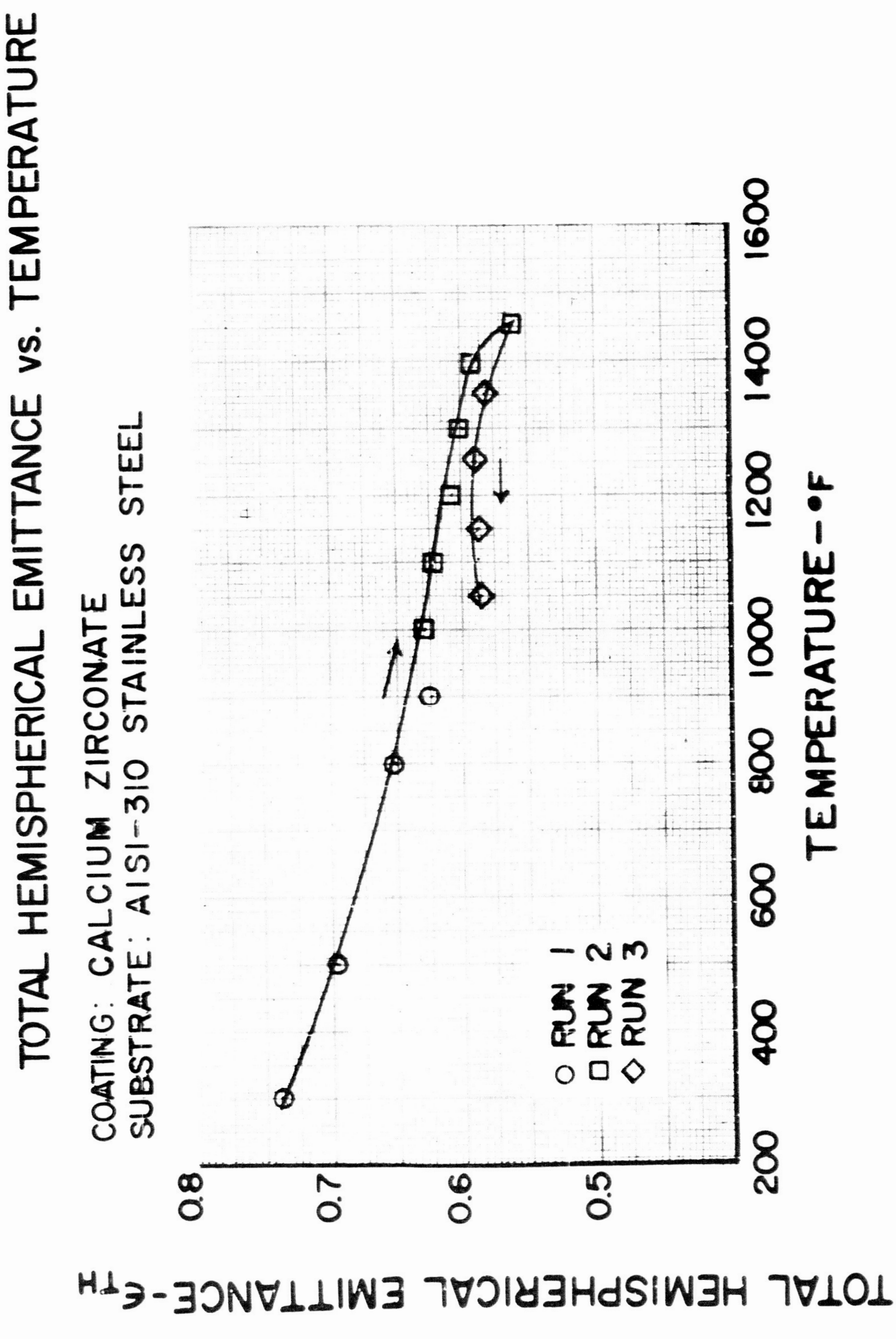

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: CALCIUM ZIRCONATE
SUBSTRATE: AISI-310 STAINLESS STEEL
○ RUN 1
□ RUN 2
◇ RUN 3
0.8
0.7
0.6
0.5
200
400
600
800
1000
1200
1400
1600
TEMPERATURE — °F
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}

Figure 155

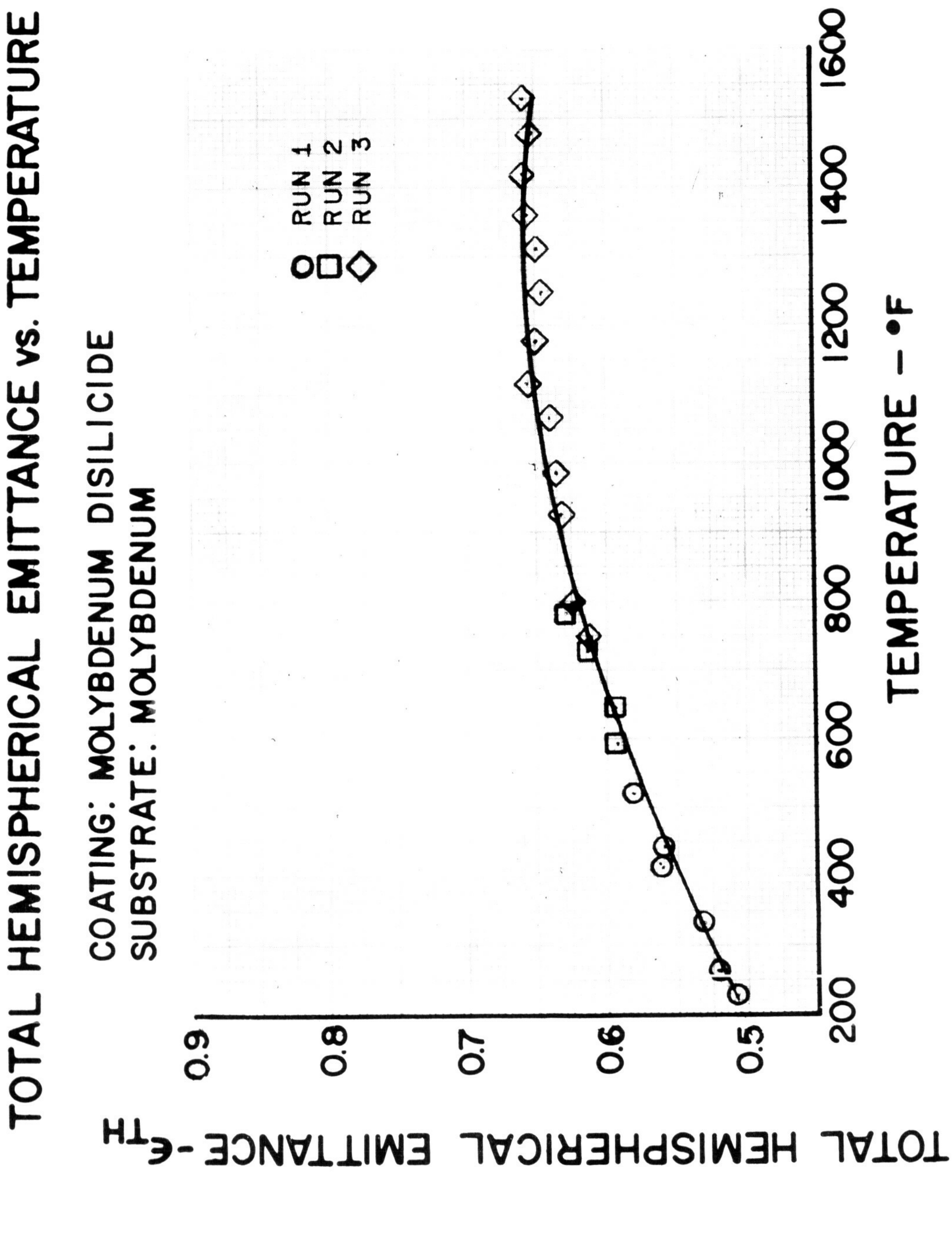

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: MOLYBDENUM DISILICIDE
SUBSTRATE: MOLYBDENUM
RUN 1
RUN 2
RUN 3
TOTAL HEMISPHERICAL EMITTANCE - ϵ_{TH}
0.9
0.8
0.7
0.6
0.5
200
400
600
800
1000
1200
1400
1600
TEMPERATURE — °F

Figure 156

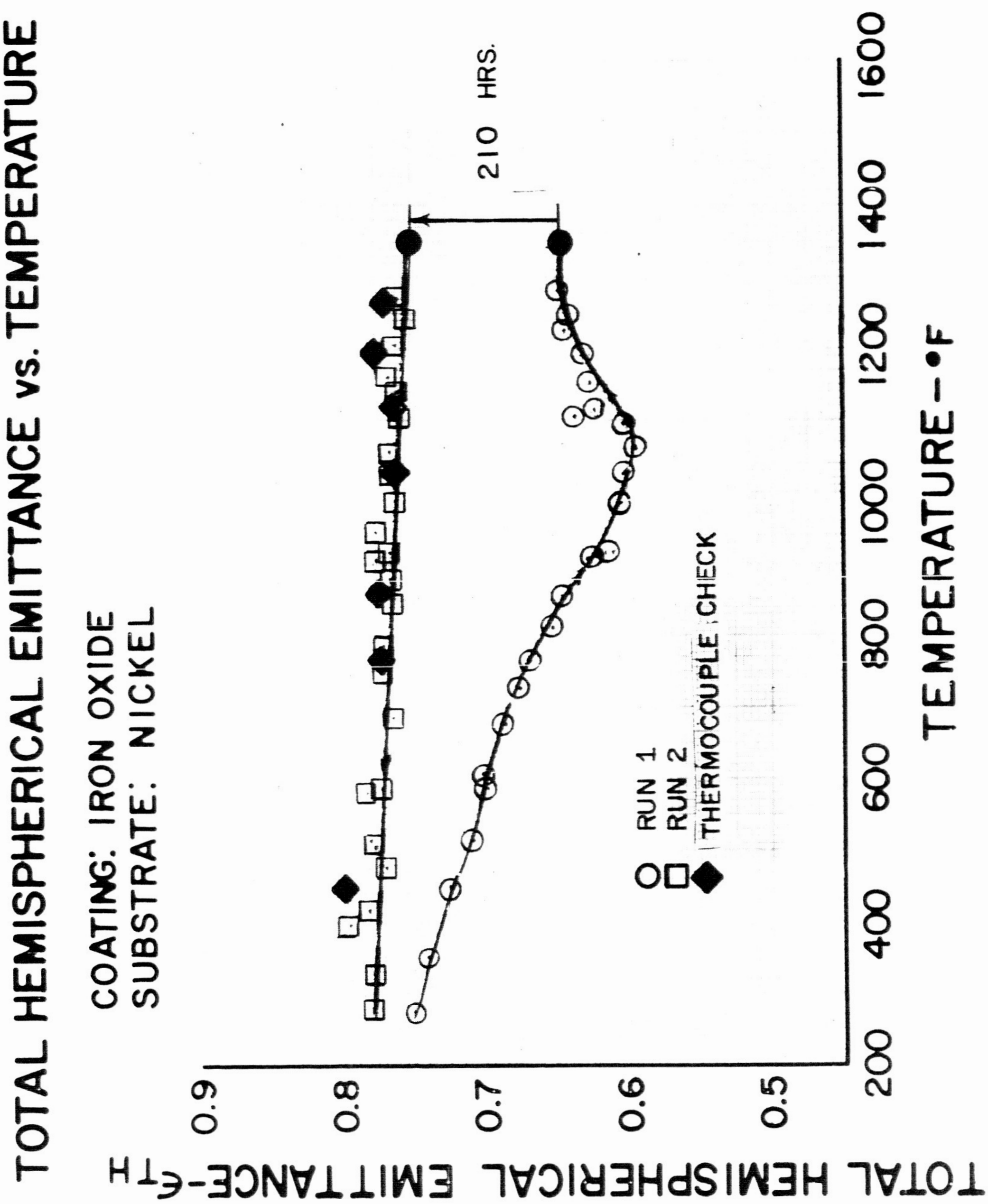

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: IRON OXIDE
SUBSTRATE: NICKEL
210 HRS.
RUN 1
RUN 2
THERMOCOUPLE CHECK
0.9
0.8
0.7
0.6
0.5
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
200
400
600
800
1000
1200
1400
1600
TEMPERATURE — °F

Figure 157

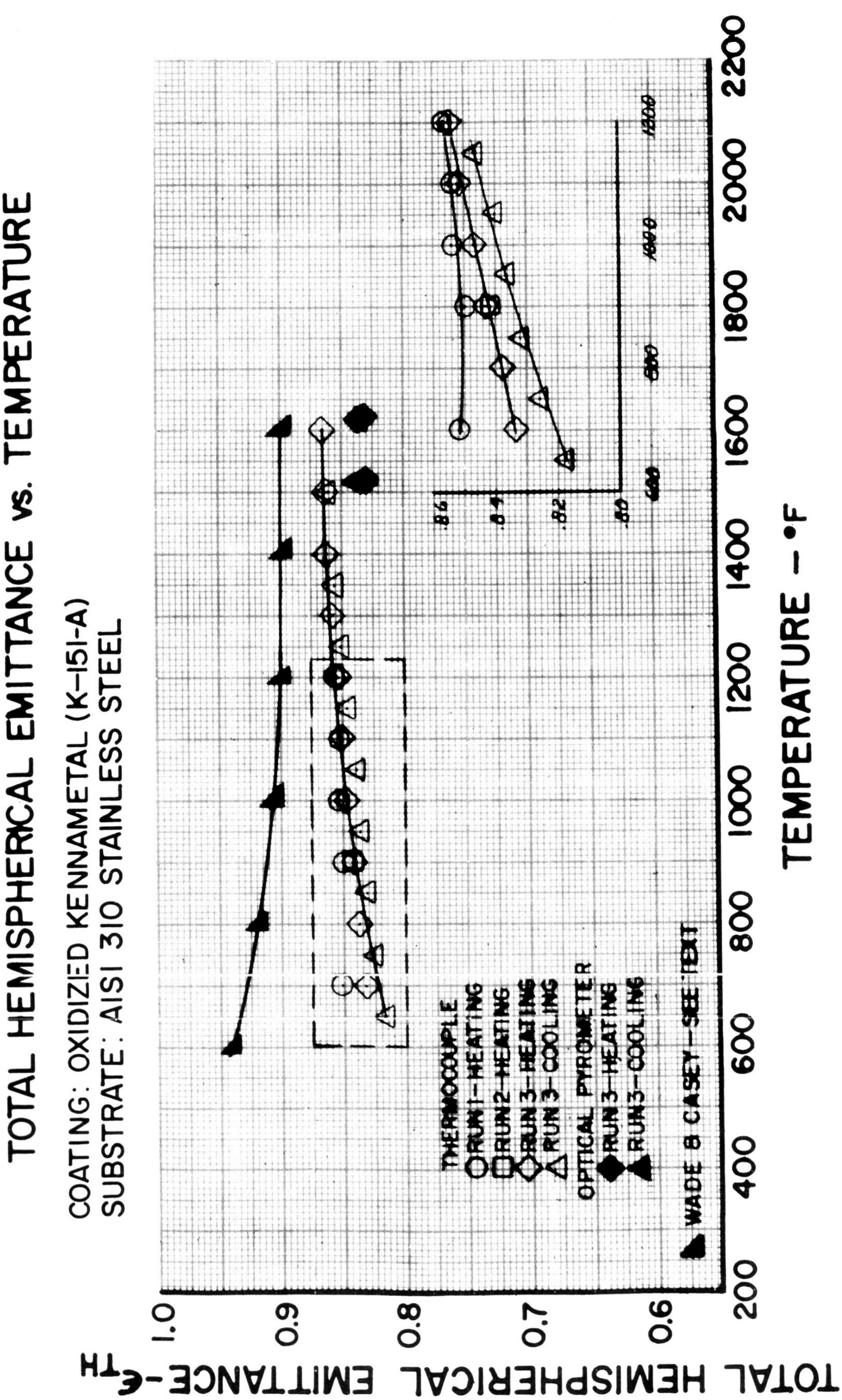

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: OXIDIZED KENNAMETAL (K-151-A)
SUBSTRATE: AISI 310 STAINLESS STEEL
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
TEMPERATURE — °F
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
THERMOCOUPLE
RUN 1-HEATING
RUN 2-HEATING
RUN 3-HEATING
RUN 3-COOLING
OPTICAL PYROMETER
RUN 3-HEATING
RUN 3-COOLING
WADE & CASEY-SEE TEXT
.86
.84
.82
.80
600
800
1000
1200

Figure 158

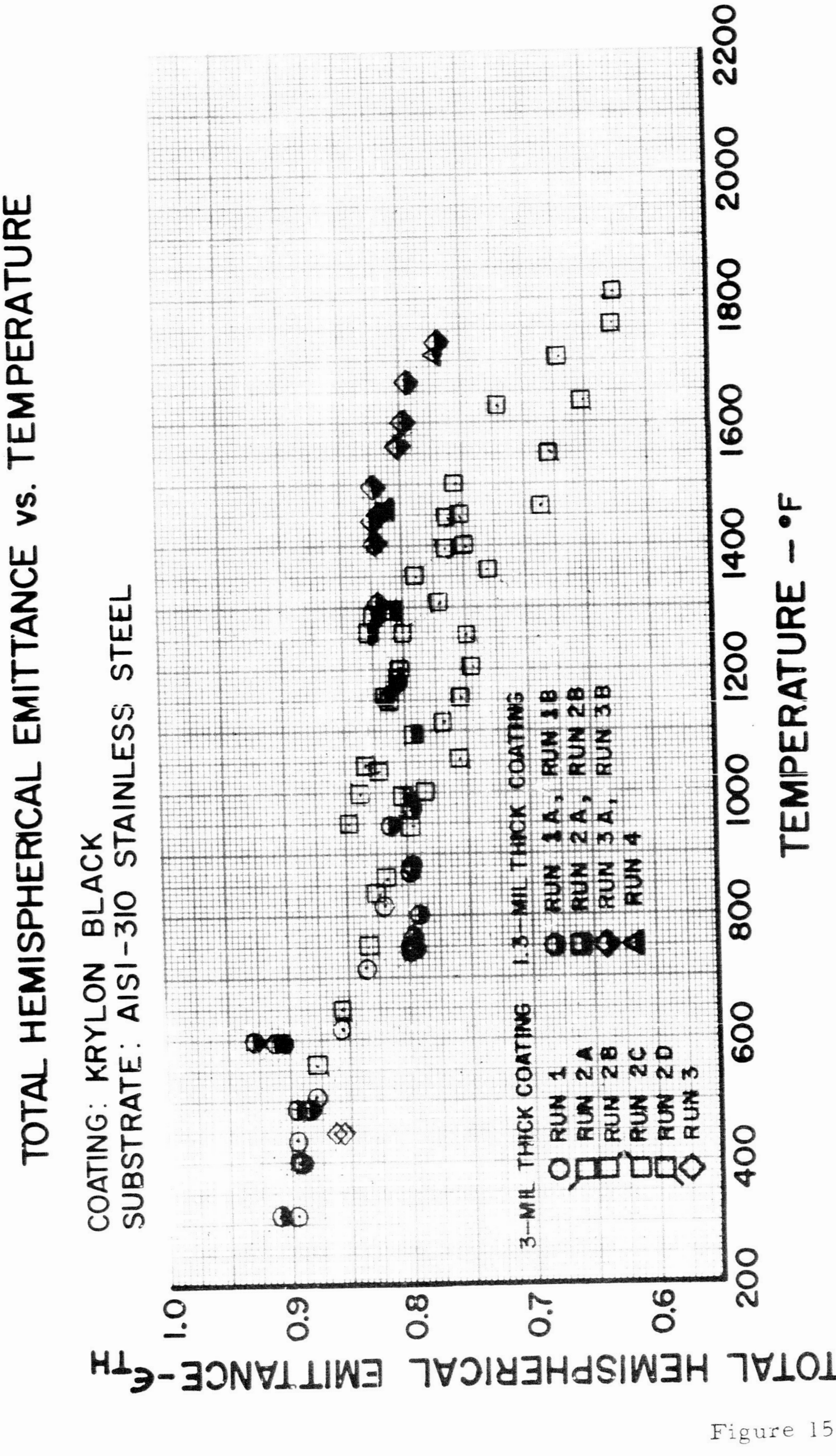

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: KRYLON BLACK
SUBSTRATE: AISI-310 STAINLESS STEEL
3-MIL THICK COATING
RUN 1
RUN 2A
RUN 2B
RUN 2C
RUN 2D
RUN 3
1.3-MIL THICK COATING
RUN 1A, RUN 1B
RUN 2A, RUN 2B
RUN 3A, RUN 3B
RUN 4
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 159

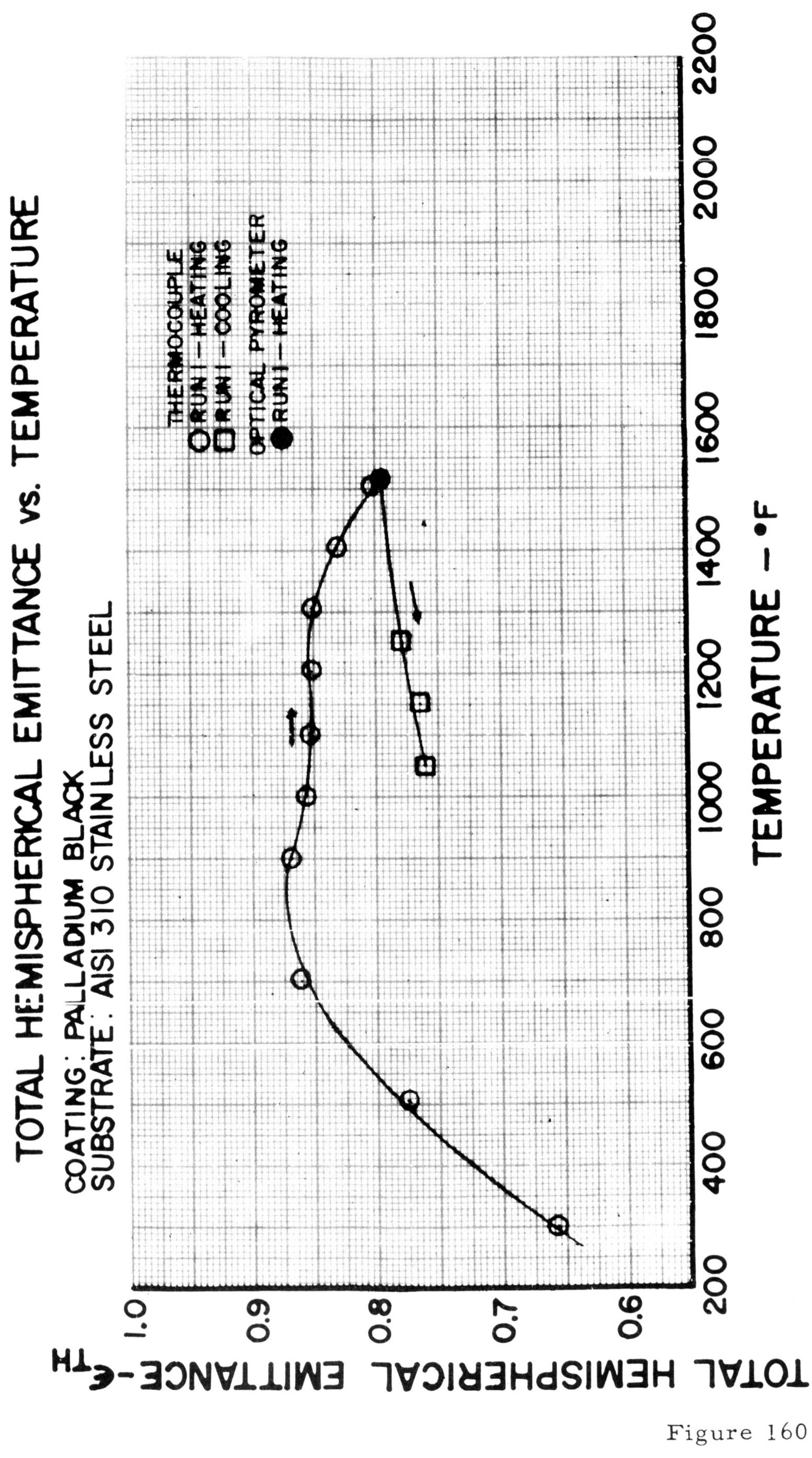

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: PALLADIUM BLACK
SUBSTRATE: AISI 310 STAINLESS STEEL
THERMOCOUPLE
RUN 1 - HEATING
RUN 1 - COOLING
OPTICAL PYROMETER
RUN 1 - HEATING
TOTAL HEMISPHERICAL EMITTANCE-ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 160

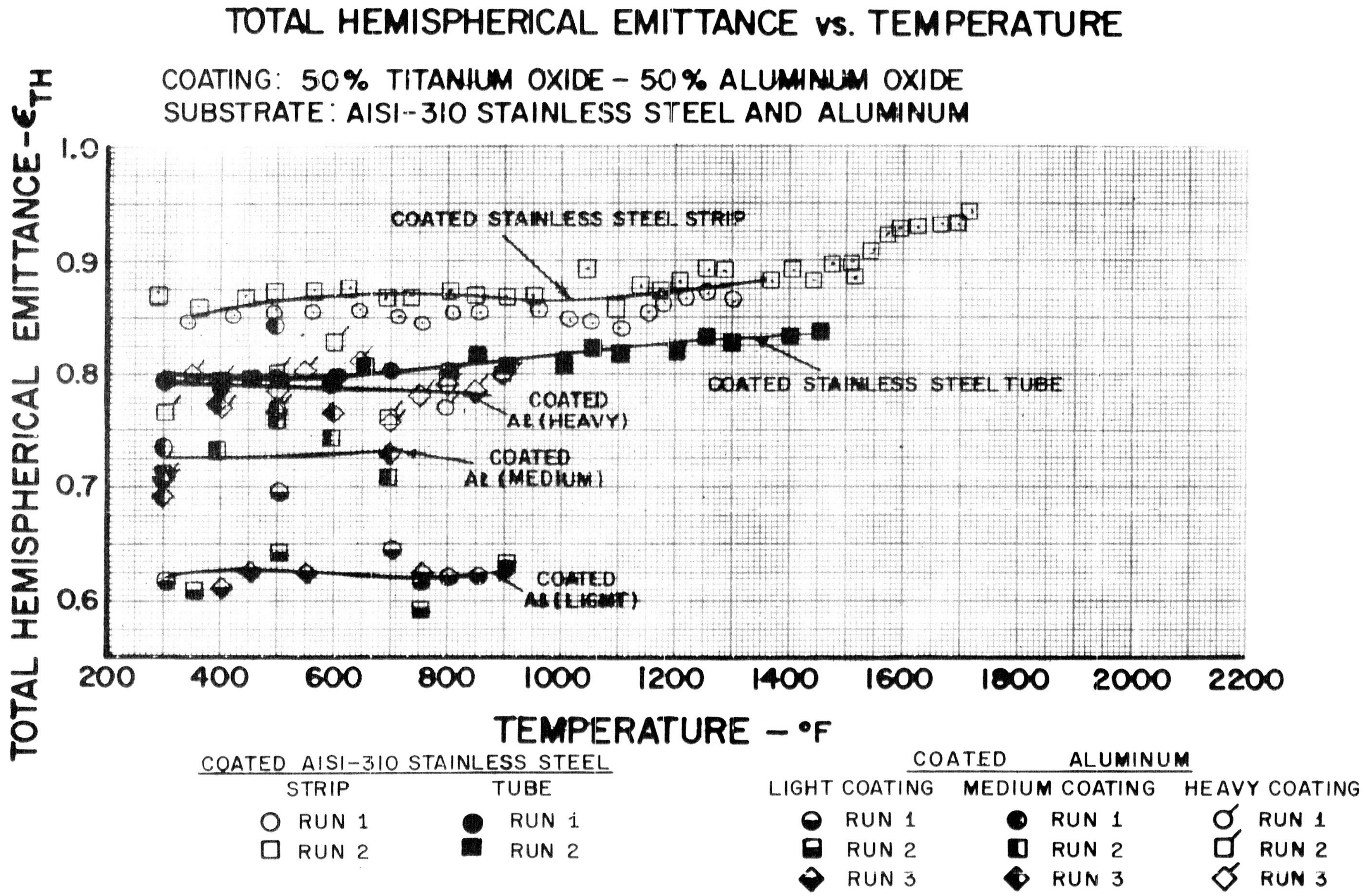

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: 50% TITANIUM OXIDE - 50% ALUMINUM OXIDE
SUBSTRATE: AISI-310 STAINLESS STEEL AND ALUMINUM
TOTAL HEMISPHERICAL EMITTANCE - ϵ_{TH}
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE - °F
COATED STAINLESS STEEL STRIP
COATED STAINLESS STEEL TUBE
COATED AL (HEAVY)
COATED AL (MEDIUM)
COATED AL (LIGHT)
COATED AISI-310 STAINLESS STEEL
STRIP
RUN 1
RUN 2
TUBE
RUN 1
RUN 2
COATED ALUMINUM
LIGHT COATING
RUN 1
RUN 2
RUN 3
MEDIUM COATING
RUN 1
RUN 2
RUN 3
HEAVY COATING
RUN 1
RUN 2
RUN 3

Figure 161

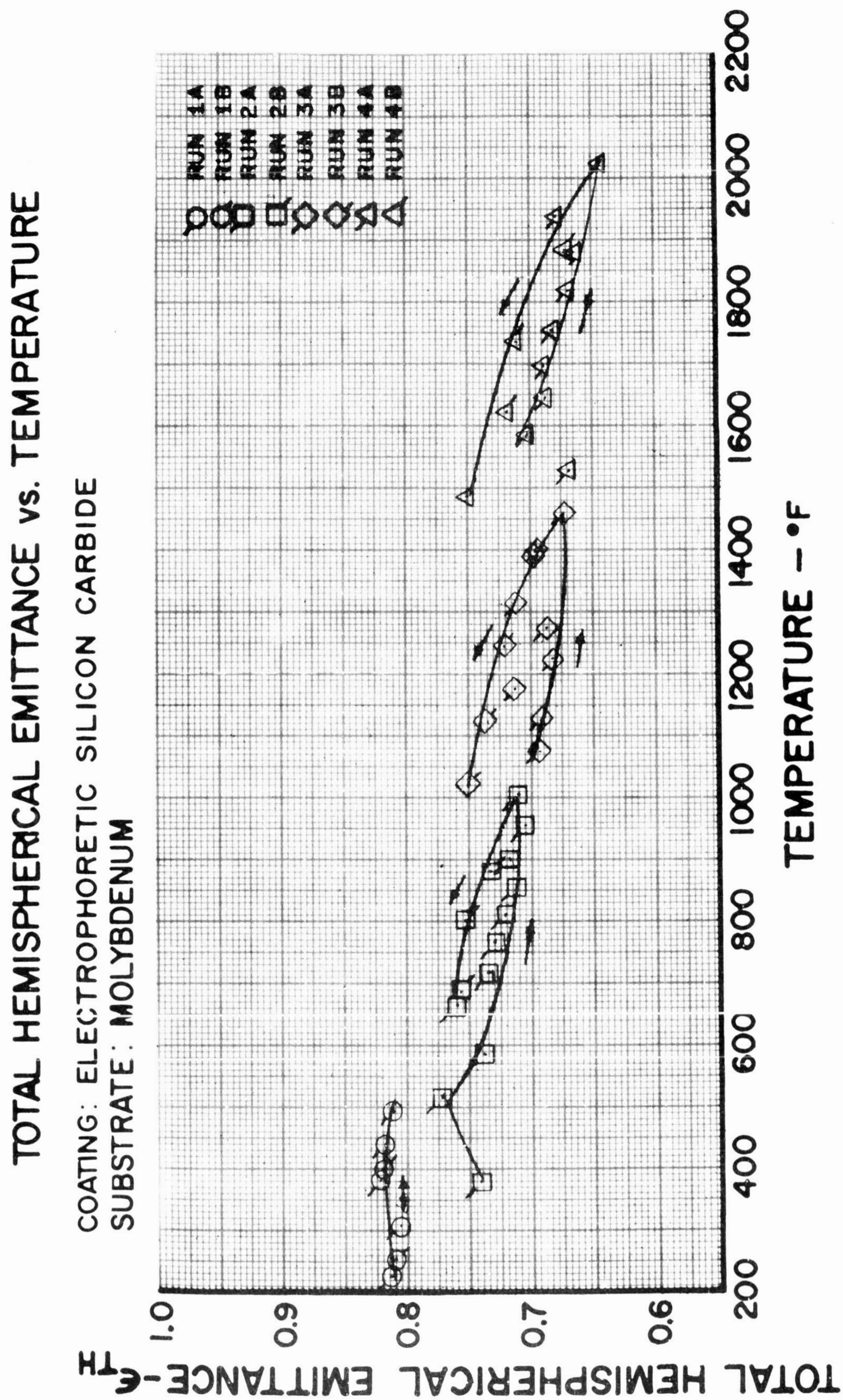

TOTAL HEMISPHERICAL EMITTANCE vs. TEMPERATURE
COATING: ELECTROPHORETIC SILICON CARBIDE
SUBSTRATE: MOLYBDENUM
RUN 1A
RUN 1B
RUN 2A
RUN 2B
RUN 3A
RUN 3B
RUN 4A
RUN 4B
1.0
0.9
0.8
0.7
0.6
TOTAL HEMISPHERICAL EMITTANCE - ϵ_{TH}
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TEMPERATURE — °F

Figure 162